THE

# AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

ART. XVIII.—*The affinities of Palæocampa* Meek and Worthen, *as evidence of the wide diversity of type in the earliest known Myriapods;* by SAMUEL H. SCUDDER.

[Read before the National Academy of Sciences, in April, 1882.]

IN an article on the structure of Euphoberia of the Mazon Creek nodules, published in this Journal a year ago, the wide departure of modern myriapods from their ancient allies, in structure, general appearance and habits, was clearly pointed out by detailed comparisons between the relics preserved in the Carboniferous rocks and the corresponding parts in modern types. A considerable number of specimens of Archipolypoda, as the ancient forms were termed, bearing out in every particular the points then brought forward, have since been examined, and have been fully represented in an illustrated memoir just published by the Boston Society of Natural History. Thanks to the local naturalists who have so well explored the beds of Mazon Creek, and who have furnished nearly all the material for the papers mentioned, I shall now attempt to show that Palæocampa is neither the caterpillar of a lepidopterous insect, nor a worm,* but a myriapod of another new and strange type. Messrs. Carr and Bliss, of Morris, Ill., have sent me three specimens of Palæocampa in fine condition, better preserved and a little larger than the original, which has

* Cf. Meek and Worthen, Proc. Acad. Nat. Sc. Philad., 1865, p. 52;—Ib., Geol. Surv. Ill., vol. ii, p. 410, pl. 32, fig. 3; vol. iii, p. 565;—Scudder, Geol. Mag., vol. v, p. 218.

been lost by fire. Messrs. Meek and Worthen have also examined a second specimen, so that five in all have now been studied. Only one of these, that procured by Mr. Bliss, is preserved in such a way as to show the legs, and, until its discovery, the affinities of this animal would necessarily have remained very obscure.

But for my previous study of the Archipolypoda of Mazon Creek, and the revelation which these ancient types give of the divergence of structure between extinct and modern forms of Myriapoda, it would have been difficult to reach the full conviction that Palæocampa was a myriapod. It is a caterpillar-like, segmented creature, three or four centimeters long, composed of ten similar and equal segments besides a small head: each of the segments excepting the head bears a single pair of stout, clumsy, subfusiform, bluntly pointed legs, as long as the width of the body, and apparently composed of several equal joints. Each segment also bears four cylindrical but spreading bunches of very densely packed, stiff, slender, bluntly tipped, rod-like spines, a little longer than the legs. The bunches are seated on mammillæ and arranged in dorsopleural and lateral rows.

The individual rods have an intricate structure; instead of being striate, as supposed by Meek and Worthen in their last examination, they are furnished externally with about eighteen longitudinal, equidistant ridges, about half as high as their distance apart; the edges of these ridges are broken into slight serrations at regular intervals about equal to the distance between neighboring ridges, the highest point of each serration being toward the apex of the spine; the body of the ridge itself appears as if broken at each serration. The intervening space between neighboring ridges is equally divided by two or three exactly similar, but miniature ridges, serrated at more frequent intervals. This serration of both larger and smaller ridges, with the apparent jointing or incision of the ridges to the base at the lowest point of each serration, gives the whole spine a jointed appearance; but a close inspection of the floor of the spine itself between the ridges shows no sign whatever of any break in its perfectly smooth surface. The diameter of the spines is only about one-tenth of a millimeter, and yet it gives room for an exquisitely regular division of its periphery by seventy or more delicate ridges, every fourth one higher than the intervening, and all broken at minute intervals by uniform serrations. The preservation of these structures from Carboniferous times is only less remarkable than the occurrence, apparently so near the origin of the type to which it belongs, of ornamentation of such excessive delicacy, finish, complication and regularity. I cannot discover that dermal

appendages of such delicate and specialized organization occur anywhere to-day among arthropods, unless it be when developed as scales, as in Lepidoptera, and occasionally in other groups of hexapods; some chætopod worms have indeed hairs of curious asymmetrical structure, often very delicate and somewhat specialized, but never, so far as I can learn, to nearly so high a degree as here. The collection of these rods into fascicles is also not a little curious, and is again a feature known now in arthropods only in a few instances, such as some tufts of hairs in lepidopterous caterpillars like Orgyia; or the pencils of hair-like scales in the males of some perfect Lepidoptera, e. g. at the tip of the abdomen in Heliconia, Danais, Agrotis, Leucarctia, etc.; or in the terminal fascicles of barbed hairs in the myriapodan genus Polyxenus.

There is no group of animals into which such a jointed creature as this could fall excepting worms, myriapods, or the larvæ of hexapod insects. The certainty that this animal possessed a single pair of well developed legs of identical character on every segment of the body behind the first segment or head is of itself sufficient evidence to exclude it both from the worms and from the larvæ of hexapod insects. No such legs or leg-like structures occur to-day in worms, and it would be idle to look for them in their ancestors of Carboniferous times. The only approach to such an appearance in hexapod larvæ is in the young of tenthredinous Hymenoptera, where, however, a difference of great morphological significance is found between the true or thoracic legs and the prolegs or those attached to the abdomen; a difference based on one of the most essential underlying features of their structure as hexapods. No such difference occurs in Palæocampa, and it is therefore impossible to conceive of it as the larva of a hexapod insect of any sort.

In myriapods only do we find a repetition of legs of exactly similar structure on every or nearly every segment of the body;* by this test Palæocampa is a myriapod; and now that we have found ancient types of this group, like the Archipolypoda, bearing huge and bristling spines arranged in series along the sides of the body, we need not be at all disconcerted at discovering this new type, with longitudinal series of fascicles of stiff rods, although we cannot restrain our surprise and admiration at their exquisite intricate structure.

Accepting Palæocampa then as a myriapod, we may next ask what relation it bore to the myriapods of the same period and found in the same waters, and also to myriapods of to-day.

* Some smaller groups, formerly, and by some authors still, considered as belonging to the myriapods, must be excepted from this statement; their relation to Palæocampa will be discussed further on.

The differences between the stout, forked and bristling spines of the Archipolypoda and the close set but spreading bunches of highly organized stiff rods of Palæocampa appear upon the barest statement. Were it not however for the complicated ornamentation of the rods themselves, the distinction between the fascicles of Palæocampa and the spines of Euphoberia would be hardly greater than that between the latter and the long hairs of an undescribed genus of Archipolypoda which has recently fallen under notice ; so that to this feature alone we cannot grant so high an importance as to another which has already been named : the presence in Palæocampa of a single pair of legs (and consequently, to judge by analogy, of a single ventral plate) to each segment; while there are two ventral plates and pairs of legs to each segment in Archipolypoda. This is a difference of profound significance, which has separated the prevailing types of myriapods down to the present day, lying as it does at the base of the distinctions between the living chilopods and diplopods. The discovery of this type is of the greater importance because we have hitherto known nothing of any chilopodiform myriapods previous to Tertiary times, unless Münster's dubious *Geophilus proavus* from the Jura possibly be an exception.

In studying the Archipolypoda we necessarily confined our comparisons with modern types to the Diplopoda, because of their common possession of the fundamental feature just named; in the same way the comparisons between Palæocampa and recent forms must be reduced to the common features or the radical distinctions which appear in studying the Chilopoda. Now although the structure of Palæocampa can be far less perfectly known than that of the equally ancient Euphoberia and its allies, enough can be seen to point conclusively to wide and important differences between it and modern Chilopoda.

In Chilopoda, of which the modern scolopendra or centipede is the type, the body is always depressed, formed of many segments, rarely as few as sixteen behind the head, each of which is compound, being formed of two subsegments, one of them atrophied and carrying no appendages; both dorsal and ventral plates are coriaceous, of nearly equal width, and possess no armature whatever excepting the simplest hairs, which are occasionally scattered over the surface. The larger subsegment bears a single pair of legs, which are composed of five slender, cylindrical, subequal joints beyond the coxa, and armed with a single apical claw ; they are attached to the interscutal membrane uniting the distinct dorsal and ventral plates of each segment and are therefore separated by the entire width of the broad ventral plates. The hindmost legs are transformed to

anal stylets, while the first two pair are more profoundly transformed to subsidiary mouth-parts, the first becoming palpi and the second stout nippers. The head, really composed of eight primitive segments, is apparently made up of two, each of which is generally of about the same size as the body segments and as distinctly separated: the stout biting jaws, composed of the second pair of legs, spring from this second segment of the head, and the palpi or first pair of legs from the hinder part of the first cephalic segment; the anterior part of the same bears the many-jointed simple antennæ.

Passing now to the comparative study of Palæocampa, we find that its body was in all probability cylindrical, composed of a limited number of segments behind the head, and the head itself, considerably smaller than the body segments, is composed of only a single apparent segment. The legs of the segment immediately succeeding it are in every respect like those of the rest of the body, and have nothing whatever to do as auxiliary to the mouth. In this point alone we have a distinction as wide and incisive as any which separate the modern Diplopoda and Chilopoda. In the body segments we discover no trace of anything more than a simple ring without subdivision, but as the specimens indicate a coriaceous structure like that of modern Chilopoda, and no trace of the division between the dorsal and ventral plates can be seen in any of them, the separation of the segments into two sub-segments, as in Chilopoda, one of them greatly atrophied, could hardly be apparent did it exist. But on the other hand, as we regard the second subsegment of Chilopoda as atrophied, we should expect to find it fully or partially developed in these creatures, which of all known ancient types are certainly the most closely related to them. Yet we find here no sign of anything more than the simplest possible, uniform, leg-bearing segments, and of a very limited number. In one feature however, they are not so simple as in Chilopoda: for, as stated, each is provided on each side with two pairs of mammillæ, supporting very large bunches of spreading rods, and the rods themselves sculptured in a very remarkable way. This distinction between the two types, though more striking and noticeable than any other, is in itself by no means so important as the others, but may be added to the catalogue; and it must have some weight, from the total absence of appendages of any sort (beyond scattered hairs) from the dorsal plates of Chilopoda. The position of these rows of fascicles and of the legs indicates that the ventral plates were only a little narrower than the dorsal, and probably of about the same extent as in the Archipolypoda; in this respect they would not differ to any important degree from modern Chilopoda. The legs were different in form, but their

poor preservation in the only specimen in which they have been seen prevents any thing more than the mere statement of the following difference: while the legs of Chilopoda are invariably horny, slender, adapted to wide extension and rapid movement; those of Palæocampa are fleshy, or at best subcoriaceous, very stout and conical, certainly incapable of rapid movement, and serving rather as props.

These differences, which underlie every part of the body that is preserved in Palæocampa, show that while the general accordance of grand features compels us to look upon Palæocampa as a precursor of the Chilopoda, we must separate it from them in the same way as we separate the Archipolypoda from the Diplopoda. For such a group the name of Protosyngnatha is proposed, indicating its ancestral relations to the chilopods, or Syngnatha, as they were called by Latreille.

There are, however, two aberrant groups of living animals more or less closely related to myriapods, and placed with them by some authors, with which also we should compare Palæocampa. The first of these is Peripatus, our knowledge of which has been so much increased of late years, and especially by the researches of Moseley.

In external appearance Peripatus resembles an annelid, but is furnished with a pair of long, jointed antennæ, and with numerous fleshy, tapering legs, each armed at tip by a pair of claws; the legs, set wide apart, are obscurely jointed, the joints being perceptible only at the extreme tip and on the apical half of the inner side, above which are the large elongated openings into the nephridia. The entire body is of a leathery texture with no external sign of segments, or of the separation of the head from the rest of the body, except the appendages: namely, the legs, the nephridia opening on the legs, and the ordinary appendages of the head. The same is true when the internal structure of the body is examined, for neither in the disposition of the muscles nor of the tracheal apparatus does it appear that one could judge whether a pair of legs represented one or more segments of the body; even in the nervous system it is only indicated by a small ganglionic swelling next each pair of legs. The tracheæ are like extended cutaneous glands, independent of one another, and scattered over the body, and the longitudinal muscles show no regular segmental breaks. This weakness of segmental divisions is nowhere paralleled among hexapods, arachnids or myriapods, and is an indication of very low organization among arthropods generally. The number of legs indicates from 15 to 35 segments in the body, according to the species. The first pair, as they are developed in the adult, are functionless as legs, and are situated (in the specimens I have examined—a South American

species, probably *P. Edwardsii*), midway between the antennæ and second pair of legs, and not only outside of but at some distance from the mouth parts, so that the latter are not furnished with auxiliary appendages borrowed from a segment behind the first, as in chilopods; this is further proven by the development of these parts in the two groups. The body is profusely covered above with corrugated papillæ, without regular distribution.

From this it will appear that Palæocampa differs in many essential features from Peripatus, and in most at least of these shows a higher organization. The segments are well separated from one another, and the head is distinctly marked. The number of segments is much less, and each bears clusters of appendages of a highly specialized character. Although no spiracles are present in the remains we have of Palæocampa, it is clear that respiration must have been effected through linearly disposed openings; since the muscular or mechanical requirements for the movement of a completely segmented body (especially if, as in Palæocampa, the segments bear a heavy armature), forbid the miscellaneous distribution of tracheæ, and demand a well-developed system with the same linear arrangement which we find in the armature. The best that can be said of the respiratory apparatus in Peripatus is that the tracheal bundles show a tendency toward "a concentration along two sides of the body, ventral and lateral." The possession, however, in each type, of a single pair of legs to every segment behind the head indicates an affinity which cannot be overlooked, and which is the more interesting since one of the types is very ancient and the other is universally looked upon as an existing survivor of an ancient type. The form of the body and of the fleshy legs is also similar, but these are minor points; and however close the agreement between these forms we cannot look upon Palæocampa, with its undoubtedly well-developed tracheal development, as in any sense the genetic predecessor of Peripatus, for the generally distributed tracheal apertures of the latter could not have developed from a serial disposition, without a degradation of type which, as Moseley points out, many other features combine with this to disprove. It may also be added that while the legs of Palæocampa are poorly preserved in the only specimen which gives a side view, the presence of nephridial openings, of such an extent and in such a place as in Peripatus, could hardly fail of detection, and they are entirely absent. The presence of these in Peripatus is one of the marks of their inferior organization, or rather of their alliance to an inferior type, the annelids.

The other aberrant group which we must specially notice is Scolopendrella, placed at first among Chilopoda, but recently

shown by Ryder and Packard to differ from them in very important features, in some at least of which it agrees with Palæocampa. The researches of these naturalists, as well as the earlier observations of Menge, clearly prove that it must be separated from the myriapods altogether, and that it is certainly provided with many points of affinity to the Thysanura. Ryder suggests for it an independent place between the Myriapoda and Thysanura under the name Symphyla. Packard, with better reason, would place it within the Thysanura, under which head he would also include the Collembola and Thysanura proper, or Cinura, as he terms them.

Scolopendrella, as these authors point out, differs from the Chilopoda in that the appendages of the segment behind that furnishing the mouth-parts proper do not serve as auxiliary organs for manducation, but are developed, like those of the succeeding segments, as legs, while the mouth parts resemble those of Thysanura, and differ from those of Chilopoda; indeed the whole head is decidedly thysanuriform; the legs are provided with a pair of claws, and the terminal segment bears a pair of caudal stylets with a special function. Besides these points the possession of a collophore is distinctively thysanuran, and the position of the stigmata, between the legs, is different from the position they uniformly maintain in Chilopoda, while it only adds to the great irregularity of place seen in Thysanura. On the other hand, the identity of form in the thoracic and abdominal segments, the full development, upon the abdominal segments, of jointed legs like those of the thoracic segments, and the occasional alternation of leg-bearing and apodal segments in the abdomen, are striking marks of its real affinity to the chilopods. Abdominal appendages, homologous with legs, but unjointed, do, however, occur in Thysanura to a greater degree than in other hexapods, so that we can hardly refuse to admit these polypodous creatures as lowest members of the sub-class of insects proper, although they are the only non-hexapodal type.

Now the separation of the head and its appendages from those of the next succeeding segment distinguishes Palæocampa from the chilopods in the same way as it does Scolopendrella; so, too, the segments behind the head in Palæocampa and Scolopendrella, alone of all arthropods in which the head is thus clearly separated, agree in showing no distinction whatever between what may be looked upon as thoracic and what as abdominal, whether in the form of the segment itself, or in the appendages of the segments. These are certainly fundamental points, but when we have mentioned them we have reached the end of all possible affinities, or points of resemblance, unless we may consider the minute structure of the

rods in the fascicles of Palæocampa paralleled by the well-known delicacy of organization of the scales in other Thysanura, though they do not exist in Scolopendrella. The limited number of abdominal segments might be looked upon as a further point were it not that the number is even less than in Scolopendrella or in the Cinura; and that the Pauropida among diplopod myriapods have in some instances even a still smaller number. On the other hand, the character of the legs, the apparent absence of a double claw at their tip, the peculiar armature of the fascicled rods, which forms so striking a feature in Palæocampa, the want of any caudal stylets, and the complete uniformity of the segments of the body unprovided with distinct dorsal scutes, distinguish Palæocampa not only from Scolopendrella but from all Thysanura whatever; the general form of the body, too, is altogether different from anything occurring there, even its cylindricity being foreign to the Thysanura, excepting in their highest types among the Collembola. It seems therefore clear that the points of affinity between Palæocampa and Scolopendrella, with the single exception of the separation of the head and its appendages from the body, are precisely those in which Scolopendrella is chilopodan, and that the assemblage of features which our fossil presents are therefore chilopodan rather than thysanuran.

Regarding Palæocampa then as a myriapod, though of a type very distinct from any known, whether living or fossil, we are brought face to face with two remarkable and somewhat parallel facts: First, that *in this ancient myriapod*, as old as any with which we are acquainted, carrying us back indeed as far as any traces of wingless tracheate arthropods have been found, and therefore presumably not far from the origin of this form of life upon the earth, *we find dermal appendages of an extraordinarily high organization*, more complicated, as we have pointed out, than anything of the sort found in living arthropods, excepting the more varied but not more exquisite scales of several orders of hexapods; a form of appendage which it would seem, on any genetic theory of development, must have required a vast time to produce, but which we now seem to find at the very threshold of the apparition of this type of arthropod life.

Second, that *at this early period*, in marked contrast to what we find in other groups of articulated animals, *the divergencies of structure among myriapods was as great as it is to-day*. This is the more surprising because we possess only imperfect remains of a few types, and yet from what we already know of the Archipolypoda on the one hand, and of the Protosyngnatha on the other, they are found to differ quite as much as the Diplopoda and Chilopoda, and in points fully as important as

those which separate so sharply these great modern groups. Whether they are to be looked upon, one as the ancestor of one, the other of the other, of these modern groups, is another question. It would certainly be reasonable to consider the Archipolypoda as the common ancestors of both the Chilopoda and Diplopoda; and possibly on the Protosyngnatha as the descendants on one line of a primitive type which, on another line, has retained its integrity up to the present day in Peripatus (and on possibly a third line has reached Scolopendrella); while on that which produced Palæocampa it has not, so far as we know, survived the Carboniferous epoch. With the facts of structure of ancient and modern types now before us, we are compelled, on any genetic theory, either to presume a great acceleration of development in earlier times or to look for the first appearance of myriapods at a vastly remoter epoch than we have any reason to do from the slighter hints in the rocks themselves—a period so remote as to antedate that of winged insects, which are now known from rocks older than any which have yielded remains of myriapods. In a memoir on Devonian insects, the concluding portion of which was republished in this Journal,* I showed the probability, on developmental grounds, that some of the Carboniferous insects, "together with most of those of the Devonian, descended from a common stock in the Lower Devonian or Silurian period; and that the union of these with the Palæodictyoptera (of the Carboniferous), was even further removed from us in time." The structural relations of myriapods and hexapods render it probable that the former preceded the latter; and in complete accordance with this expectation, the structural relations of the oldest fossil myriapods indicate their apparition at a period earlier than that to which the winged insects are hypothetically assigned. This would compel us to consider the earlier type as aquatic, for which we have presumptive evidence in the structure of the Euphoberidæ, and renders it all the more surprising that the penetrating researches of the last thirty-seven years, since the first Carboniferous myriapod was discovered, have not yielded the slightest trace of fossil myriapods below the Coal measures. This discrepancy between fact and hypothesis should never be lost sight of, and should stimulate to more searching investigations, particularly of those articulates of the older rocks whose affinities have not been satisfactorily settled.

* Vol. xxi, p. 117.

ART. XIX.—*A Source of the bituminous matter in the Devonian and Sub-Carboniferous Black Shales of Ohio;* by EDWARD ORTON, Columbus, Ohio.

THERE are three strata of black shale in the Devonian and sub-Carboniferous series of Ohio, viz: the Huron and the Cleveland shales of Newberry and the Waverly Black shale of Andrews. The latter name, I have followed Meek in replacing by the designation Berea shale. It constitutes the base of the Cuyahoga shale of Newberry. The first of these strata is unquestionably Devonian in age, and the last is referred without dispute to the sub-Carboniferous series. To the same division is referred the Cleveland shale by Newberry, on account of the presence in it of fishes of sub-Carboniferous type. In northeastern Ohio the Cleveland shale is separated from the underlying Huron shale by the Erie shale of Newberry, a mass of green and blue shale which ranges from nothing to 1,000 feet in thickness. Dr. Newberry showed, a number of years since, that the Erie shale thinned out as it was followed westward from the northeastern counties, and disappeared altogether in Huron county, letting the black Cleveland shale down, by overlap, upon the underlying Huron shale, which is also black. I have since shown that it is this compound stratum, the Cleveland (Erie), Huron shale, that constitutes the great black shale of Ohio, that extends from Lake Erie southward to the Ohio River and beyond. In central and southern Ohio, at least, it seems impracticable to divide it, and to refer one portion to the Devonian and another to the sub-Carboniferous, from the lack of characteristic fossils or stratigraphical marks in the formation. The average thickness of the compound formation through the State is probably not less than 300 feet.

The Berea shale, which directly overlies the Berea Grit, ranges from 15 to 50 feet in thickness, and is separated from the great black shale by an interval of 100 to 150 feet, the interval being occupied by the Bedford shale and the Berea Grit of Newberry. In northern Ohio the upper boundary of the Berea shale is not well defined. In central and southern Ohio, it is sharp and distinct.

These several beds of shale contain, as their color indicates, a notable quantity of organic matter. The proportion ranges, according to published analyses, from 8 to 21 per cent, the higher proportion having been found in some phases of the Berea shale.

The sources of this bituminous matter have not as yet been made apparent. The presence of conodonts and fish remains

in the upper or Cleveland division of the great black shale, and also in the Berea shale, has been noted as one source of this organic matter, and occasional strap-shaped leaves of fucoidal origin occur in both formations, but neither of these sources seems at all adequate to the supply. Dr. Newberry has referred to a "sargasso sea" as affording the most probable explanation of the facts involved, and offers "the suggestion that the carbon of the shale was derived from vegetation which lined the shores and covered the surface of a quiet and almost land-surrounded sea." This vegetation he is disposed to regard as exclusively marine. (Geology of Ohio, vol. i, pages 155–6.)

Professor E. B. Andrews, in the Ohio Geological Report of 1869, also discussed the problem briefly. He believed that the water in which the shale was deposited must have abounded in minute forms of vegetable or animal life, but he added that a search for these forms had been unrewarded.

Within the last few months I have discovered a new source, and, as I believe, a chief source of the bituminous matter of these shales, in certain minute forms of vegetable origin which they contain in vast numbers. I herewith present a brief account of the discovery and of the facts involved.

In 1881, Mr. J. A. Flickinger, County surveyor of Ashtabula county, Ohio, sent me specimens of the drillings from a deep well which was being sunk at Kingsville, Ashtabula county, in the search for petroleum or gas. For 800 to 900 feet the drill passed through blue shale, quite uniform in appearance, and destitute of fossils. This is evidently the Erie shale of the Ohio scale.

At about 900 feet layers of black shale began to be met, and they continued to occur for 300 feet, when the boring was stopped.

In examining with a microscope the fragments of this black shale I found many of them covered and filled with yellow, translucent discs, ranging from one one-hundredth to one two-hundedth of an inch in their longest diameters. The discs present the appearance of empty and flattened spherical sacs. When the shale is cut transversely, the discs appear as elongated and translucent yellow bars, roughly parallel to the bedding, and sometimes they present the appearance of flattened hoops.

The discs have a decidedly resinous appearance, but they yield but slowly, if at all, to ordinary solvents. When the shale is raised to a red heat, they disappear entirely, leaving empty pits in the shale.

At some points, and especially at a depth of 1,000 feet, the shale is so charged that every fragment contains them, while

some pieces acquire a rusty or yellowish color, even to the naked eye, from their aggregation.

At a later date I found the upper member of the great black shale in the vicinity of Columbus (the Cleveland shale), charged with identical forms. In addition to the discs already described there are occasionally found in this stratum flattened spheroids, considerably larger in size and somewhat darker in color, but obviously referable to the same group of forms. These larger bodies range from one fifty-fourth to one sixty-fourth of an inch in their long diameters, and consequently are discernible by the naked eye when they are well located. They burn with a flame and leave no residue.

I have lately examined specimens of the black slates of the three horizons named, viz: the Huron, the Cleveland and the Berea shale, from every part of the State in which they occur, and I find forms agreeing in general characters with those first described, everywhere present and often in great numbers. I am not now prepared to make computations of the number present in any measured volume of the shale, but the proportion is a notable one in many instances.

As to the nature of these bodies there seems no reasonable room for doubt. They agree in general characters with the spore-cases of several of the lower orders of plants. The descriptions given by Williamson of the lycopodiaceous spores in English coals will apply without change to the general appearance of these forms, in sections parallel and transverse to the bedding, but they lack the peculiar markings and shapes that characterize lycopod spores in particular, and will probably find their place in some lower group.

Different sizes have been recorded for these forms, but there is no doubt that all of them are macrospores. The finely-divided carbonaceous matter that is associated with them in the shale may represent the microspores.

There is nothing new in the detection of spores in formations that agree in general character with these black shales. Williamson records the presence of lycopod spores in great numbers in British fire-clays and iron ores. Binney has urged the view that the Boghead Cannel and other similar deposits must be referred to microspores for their origin.

The two inflammable Australian minerals, white coal and tasmanite, have been shown by microscopic sections to owe their inflammability to the resinous spores of lycopodiaceous plants. These minerals belong to a much later geological period than the Carboniferous. The tasmanite above referred to is a shale containing 26 to 30 per cent of combustible matter. It is therefore but little richer than the best portions of our Berea shale, which contain 21·4 per cent of bituminous matter.

I do not know, however, that spores have heretofore been shown to supply bituminous matter in large amount to any formation older than the Carboniferous.

If the construction placed upon the facts recorded in this paper shall be accepted, and vegetable spores shall be recognized as a chief source of the bituminous matter of these black shales, the perplexing question as to their origin will have been carried one step further back.

These black bands of the Huron shale lie geologically not far below the Venango oil-sands of western Pennsylvania. The resinous substances now described seem to offer an adequate and natural source of the petroleum and gas with which these rocks are charged. Dr. Newberry has long insisted on the adequacy of these beds and of these only for this supply, and he has sagaciously noted the fact that the carbonaceous matter of these shales consists mainly of hydro-carbons. The discovery of an ample supply of resinous spores within the substance of the shales certainly strengthens the claim that has been made for them as the main source of the valuable accumulations of oil and gas of the sandstones and conglomerates that overlie them.

P. S. Since writing the above I have learned, through correspondence with Principal J. W. Dawson of Montreal, that he has already recognized and described the most characteristic of the forms above referred to under the name of *Sporangites Huronensis*. (See this Journal, April, 1871, page 257.) The specimens on which his description was founded came from the bituminous shale of Kettle Point, Lake Huron. A bed of brown shale, burning with much flame, of Upper Devonian age, from twelve to fourteen feet in thickness, occurs here. The spore-cases are described as flattened, disc-like bodies, scarcely more than one-hundredth of an inch in diameter, slightly papillate externally, with a point of attachment on one side and a slit more or less elongated and gaping on the other. In sliced sections of the rock, they appear yellow like amber and show little structure, except that the walls can sometimes be distinguished from the internal cavity and are seen to enclose patches of granular matter which may be the microspores.

Dr. Dawson has kindly furnished me with a piece of the Kettle Point shale. The spore-cases appear to be identical with those first recognized by me, coming from Kingsville, Ohio. In the large range of rock which I have now reported, there are apparently several species of these bodies.

Dr. Dawson refers the spore-cases to Lycopodiaceous plants, and suggests two species of Lepidodendron, the remains of which are found at the same horizon, as likely to furnish them, viz: *L. Veltheimianum* and *L. Gaspianum*.

Columbus, Ohio, June 1, 1882.

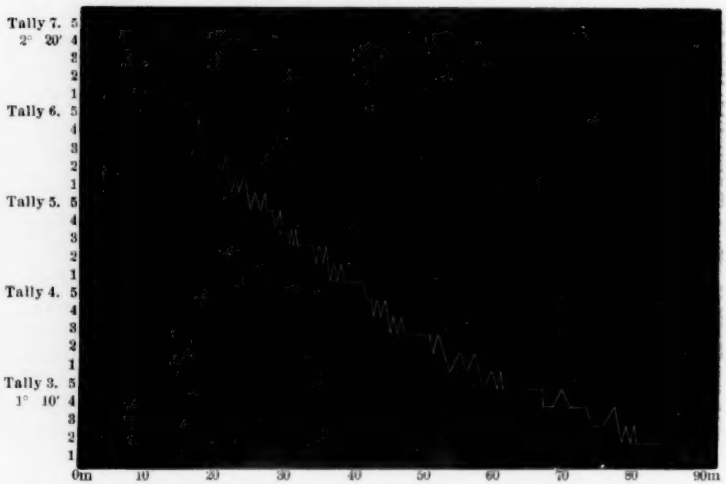
ART. XX.—*A Pendulum Study;* by O. T. SHERMAN.

"LE mode d'installation du pendule, la nature du support sur lequel il est placé, en raison de l'elasticité de la matière dont il est composé ou de sa masse relativement peu considérable, peut exercer une influence sur le mouvement du plan de suspension. Cette influence est tres-sensible pour un support en bois; . . . . elle est encore appréciable entre un pilier en pierre . . . . et le pilier très-massif sur lequel les observations ont été faite . . . . a Genève."—E. PLANTAMOUR.

The above describes pretty completely the only result which it is my fortune to draw from a series of pendulum observations taken during a northern journey. But, what is the mode of action of the disturbance? It affects the mean of the observations; can its correction be drawn from the observations themselves?

The stand with which the expedition was furnished was formed by three beams of about five inches square, and fastened by bolt and screw mutually at right angles. These are braced in each of the three coördinate planes. The pendulum case, of light wood, rested on a bracket and was secured to the upright by bolt and screw. The agate planes were fastened to a weighty, solid gun-metal casting, and it in turn by screws to the back of the case; the whole forming a support as stable as the material would allow. While studying the subject since returning, the case has been fastened to the brick wall of the clock room of the Observatory of Yale College. The connection is made through wood. The results show, if any, very little improvement over the portable stand. The pendulum itself is a Baily's bar made to beat in three-quarters of a second at Washington, D. C. It was customary in the field to measure the amplitude of the arc by making the cross wire of the observing theodolite coincide with the extremities of the arc, and noting the angle subtended. The observations were not frequent and no discrepancy was noticed. When the instrument again reached my hands it was provided with an arc divided into degree and ten-minute spaces. The scale was subjected to a critical study and the errors of the graduations tabulated. We then endeavored to trace the decrement of the arc by observations every five minutes. After making every correction it was found impossible to represent the observations by any smooth curve. The observations for the larger arcs might be fairly represented by a somewhat sinuous, the smaller arcs by a very jagged, line. Thoroughly dissatisfied with the action of this scale it was replaced by a net formed by a number of silk threads passed over two similar screws.

For better distinction the threads were divided into tallies—five black and five white. The interval between the threads was about seven-tenths of a millimeter. The observer then sitting behind the telescope made at each apparent contact of the knife edge with a thread, a signal on the chronograph at once representing the tally and thread which the knife edge seemed to touch. The result was so unforseen as for some time to cause a doubt in the mind of the observer as to its correctness. He assured himself of its reality by obtaining fairly identical results again and again. Over some threads the knife edge passed with rapidity. On others it rested for an interval increasing with the decreasing rapidity of the movement. Many it touched, passed, retouched, repassed. A representation is annexed. The abscissæ being the interval in minutes since the commencement of observation. The ordinates, the number of threads from the center.




It is interesting to compare with the above paragraph a remark of the Coast Survey Observer, who notices that the discrepancies of the separate observations of the intervals at which his pendulum reached a given arc are several times larger than can well be attributed to errors of observation. Is it not quite probable that there was in his case an indeterminateness similar to that shown in the diagram?

It seemed likely that this was due to a walking of the pendulum, such as might effect a change in the absolute position of the bar during the time of swing. I therefore fixed on the bar a small bit of looking-glass in which was reflected a scale. At the beginning of the swing a thread was set so that when

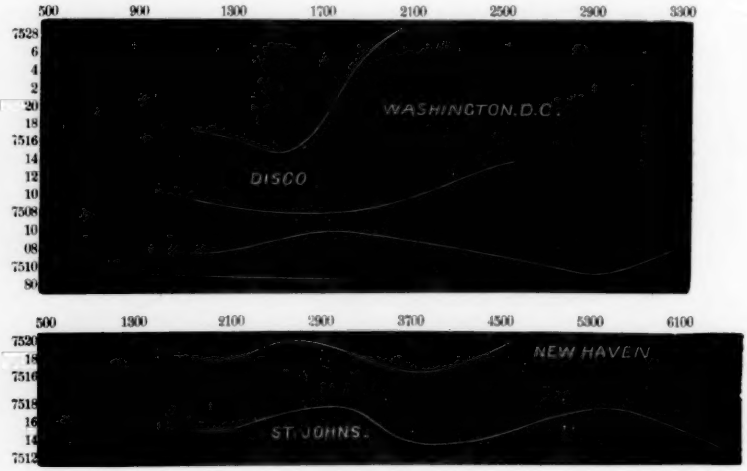
covered by the cross-wire of the telescope it bisected the knife edge. The telescope was then directed to the mirror and focused so that a division of the reflected scale was visible on the cross-wire. The pendulum was then carefully set in motion and allowed to come to rest. The position of the reflected scale was first re-examined then the telescope re-directed toward the thread. Although a hundred and twenty observations were taken no change was detected.

The only other explanation which has suggested itself is that of small movements of the stand which are not synchronous with the swing of the pendulum. In one set of observations this resulted from the nature of the ground on which the stand rested; in another it varied with the varying tightness of the joints from the dryness of the wood; in a third which has lately been called to our attention it is apparently caused by the vibration of the clock on the same wall. It has been shown that the effect of the motion of the plane of suspension due to the elasticity of the support increased the time of vibration by a constant. If, however, there are other causes for the motion of this plane than the elasticity of the support, the variation of the time is represented by

$$\Delta T=\frac{1}{2g}\int_{\varphi=}^{\varphi=}\frac{\delta^2 s}{\delta t^2}\cdot\frac{\cot\varphi}{V}\cdot\ \delta\varphi$$

where $\frac{\delta^2 s}{\delta t^2}$ represents the variation of the velocity of the motion of the plane of suspension; V, the velocity of the pendulum due to its instantaneous position. Of this differential $\frac{\cot\varphi}{V}$ passes through its series of values with each swing. If $\frac{\delta^2 s}{\delta t^2}$ has the same period the integral is evidently a non-periodic function of the arc or a constant. If, however, $\frac{\delta^2 s}{\delta t^2}$ has a period, or series of periods, which are different from that of $\frac{\cot\varphi}{V}$, the value of the integral will depend on the phase with which $\frac{\delta^2 s}{\delta t^2}$ enters: and since in the course of the observation this phase will again occur with the commencement of the period of $\frac{\cot\varphi}{V}$, the function representing the disturbance of time of oscillation should be one possessing maxima and minima disposed according to some law. Since the phase of $\frac{\delta^2 s}{\delta t^2}$ at entrance reacts on

the time of swing, the limits of the integral will be irregular with respect to the portion of $\frac{\partial^2 s}{\partial t^2}$ included, and we should have a series of minor irregularities, themselves following some law, superposed on the curve produced by the varying phase at entrance. Again, since the value and relative period of $\frac{\partial^2 s}{\partial t^2}$ and V do not necessarily decrease in the same ratio with the continuance of the observation, the amplitude and period of the disturbance should continually increase or decrease. All of these are distinct from the traces of other errors of the pendulum. This curve is a record of the variation of the time of vibration produced by the motion of the plane of suspension, and therefore a definition of the steadiness of the stand. We deal, however, with means rather than the time of single vibration, and obtain a different defining curve for different limits of the second integral. But from whatever number of vibrations our means are derived we obtain the above peculiarities.




In practice there is also another variation from the fact that the transit of the cross-wire is not coincident with $\varphi=0$. Experimentally we can obtain but an approximation to the actual curve representing $\Delta$ T, but yet certainly a sufficient approximation. To this end the observer seated with his eye at the telescope has recorded on the chronograph the time of each transit in the same direction. Frequent short breaks are indulged in. They break the rhythm and better rather than injure the observation. Then reading the sheet we have taken

(e. g.) the mean of the interval bounded by the first and thousandth transit, the second, and thousandth and second, etc. Thus including in the second interval by far the greater part of the first interval, but depending on two different observations. This served to insure against accidental errors. These values are then carefully plotted, the number of transits from the beginning being used as the abscissæ. The curves thus derived fulfill our expectations as far as we can sharply criticise a statement so general.

Furthermore, curves from the same mounting preserve their general peculiarities for different observations. For different mountings the amplitude is greater with the less stability. In the preceding diagram we represent certain of these curves for the different places of observation. The sharp and quick irregularities are omitted on account of the smallness of the scale. In fact we have not now to deal with them. Since at the time of observation we supposed ourselves dealing with synchronous motion, the curves are not complete. They serve their purpose. The curve for Washington represents the least stability; that for Disco the greatest. At Disco we give three curves. The first represents the action of the stand when first set up, the parts being dry. The stand was exposed to the weather. Between the first and second series a heavy fog had swollen the parts. Between the second and third a heavy snow storm had still further swollen the various parts. For the first installation the amplitude of the curve is at least 0·0008 of a second; for the second at least 0·0003. For the third it is indeterminate. All refer to about the same amplitude of vibration. The curve for St. Johns represents fairly the increased effect of the disturbance with decreasing arc. The same is also shown in the curves for New Haven, and the second curve for Disco. It has not seemed necessary to correct the values here represented for arc.

We venture to think, then, that while an observer who finds himself compelled to work with a mounting other than he would wish can not consider that his time is increased by a constant, yet he is in a position to detect and define the effect of the stand movements at the moment of observation. This would seem the first step toward eliminating the effect. That such an elimination can be made—at least a practical elimination—we hope to show later. We can offer as yet no experimental data of its completeness.

It is to be observed that the curves derived from this cause are distinct from those produced by the form of the knife edge. It is easily shown that for any smooth, rounding, and practically, for any slightly waving form of the edge, the time of vibration is represented by

$$t = \sqrt{\frac{l}{g}}\sqrt{\frac{1}{1+P\alpha^2}}\cos^{-1}\pm\frac{0\alpha^2+2(1+P\alpha^2)\varphi}{\sqrt{0^2\alpha^4+4(1+P\alpha^2)\alpha^2}}$$

where P and 0 are constants depending on the form of the knife edge and varying inclination of the instantaneous axis to the face of the pendulum. Such a variation, as has already been recognized (India Survey, Pendulum Operations; Coast Survey Report, 1876), is detected by a non-periodic acceleration or retardation of rate.

---

ART. XXI.—*On the Effect of Mechanical Hardening on the Magnetic Properties of Steel and Iron;* by LOUIS M. CHEESMAN.*

1. *Introduction.*—The relation between the magnetism and hardness of steel and iron has for many years been a subject of scientific investigation, and especially in the last few years many valuable results have been obtained in this connection.

These investigations, however, have been almost exclusively confined to the effect of the hardness brought about in steel and iron by the action of heat, while that which is caused by mechanical means has been left for the most part unconsidered. This is the more remarkable as the fact, that the mechanical hardening exerts an influence on the capacity to retain magnetism, has certainly been known for nearly a century. Coulomb,† who I believe was the first to publish this fact, says, in speaking of increasing the magnetic capacity by means of hardening, that "the hardness does not need to be accomplished by heating to redness and then suddenly cooling, but that a mechanical hardening as well causes an increase in the permanent magnetic moment."

In this connection should also be mentioned an investigation by Airy,‡ who informs us that the magnetism assumed by cold- and hot-rolled iron, under similar circumstances, are to each other as 6 is to 5. Lastly I would refer to a passage in one of Lamont's§ works, where we find it stated that the capacity of soft iron for induction is materially altered by a mechanical hardening. Thus, although the subject under consideration is by no means a new one, still little, if anything, beyond what has already been stated, seems to be known in regard to it; and I have therefore endeavored, at the instigation of Prof. F.

* Translation from Wiedemann's Annalen, vol. xv, 1882.

† Coulomb, mém. del'Acad. roy. des Sciences, p. 266. 1784. Wied. Galv., II. a, p. 341.

‡ Airy, Experiments on Iron Built Ships. Philos. Trans. 1839. Fortschr. der Physik., xix, p. 454. 1863.

§ Lamont's Handbuch des Magnetismus, p. 255.

Kohlrausch, to study the matter somewhat more systematically than hitherto has been done, with especial reference to the question, whether there are any qualitative differences between the effects of the two kinds of hardening on the magnetic properties of steel and iron.

2. *Division of the work.*—The work divides itself naturally into a consideration of the effect of the mechanical hardening: 1st, on the permanent magnetism of saturated magnets; 2d, on the temporary, as well as the permanent magnetism, by various intensities of the magnetizing force.

3. *Material.*—In regard to the material used it should be stated, that experiments were made with steel and iron from many sources. The kind of steel chiefly employed however, was that known as "English Silver Steel," which was obtained from Crooks Bros. in Sheffield and Manchester, in the form of wires, 330$^{mm}$ long, with the diameters 1·0$^{mm}$, 1·2$^{mm}$ and 1·6$^{mm}$. The iron magnets were cut chiefly from a long piece of soft "Commercial Iron Wire," having a diameter of 1·6$^{mm}$.

All the material, when the contrary is not stated, was softened, before being used for the experiments, by heating it in an iron box filled in with forge scales. After the box with its contents had been at a red heat for some time the fire was allowed to die out, the material remaining in the forge until it had cooled down to the ordinary temperature. After the wires had been softened every precaution was taken to prevent any unintentioned hardening.

4. *Hardening.*—The wires were hardened either by "bending," "stretching," "hammering," or "pulling" them through holes in the well-known apparatus for reducing the diameter of wires.

The last mentioned method has the great advantage of enabling us to obtain wires of different degrees of hardness with very nearly equal diameters. Thus if three wires differing in hardness are to be obtained they may be pulled, for example, wire (a) through holes [1], [2] and [3], wire (b) through [1] and [2], and wire (c) through hole [1]; they are then softened and wire (c) pulled through [2] and [3], wire (b) through [3] and wire (a) left soft, all thus having the diameter of hole [3]. This advantage, however, is more than counterbalanced by the fact, which was evident in many ways, that the hardening is very irregular.

By far the most satisfactory experiments were made with wires hardened by "stretching" them in an apparatus [Perreaux] for determining the "breaking weight," the weight being read off by an index in kilograms.

## I.—Permanent Moment of Saturated Magnets.

The general course of the experiments here was to magnetize to saturation wires having, as far as possible in the same set of experiments, the same constitution and dimensions, but differing in their hardness; then to determine their magnetic moments.

5. *Magnetization.*—The wires were magnetized by means of a large horse-shoe magnet,* and in all cases the magnetization was repeated until the deflection on the magnetometer remained constant within at least $\frac{1}{2}$ %. As great care was used to treat all wires similarly, two magnetizations were generally sufficient.

It should be stated that a series of experiments made later, the wires being magnetized by means of a coil and the current from a dynamo-electric machine, afforded results differing in no essential degree from those given here.

6. *Determination of the magnetic moment.*—The magnetic moment was determined with a small magnetometer by the Gauss deflection method, the magnets lying in such a position, west of the magnetometer, that the prolongations of their axes were perpendicular to the undeflected magnetometer needle at its middle point; the readings were taken by means of a scale and telescope.

A steel mirror, [Sauerwald, diameter $22^{mm}$] hung on a silk fiber, served as magnetometer needle.

To eliminate any unsymmetrical distribution of magnetism, as well as the zero point of the scale, the magnets were placed alternately with their north and south ends toward the magnetometer, in both positions the scale reading being taken.

The distance between the mirror and magnet was determined within $0{\cdot}15^{mm}$, and though not always the same was about $450^{mm}$; the distance between the mirror and scale was about $2000^{mm}$.

7. *Calculation of the Experiments.* — The *specific magnetism* was calculated by the following formula:

$$s=\frac{M}{m}=\frac{1}{2}\frac{r^3 T \operatorname{tg}\varphi}{l^2}\cdot\frac{1}{m}\,\mathrm{mm}^{\frac{1}{2}}\cdot\mathrm{mg}^{-\frac{1}{2}}\cdot\sec^{-1}$$

$$1+\tfrac{1}{2}\frac{}{r^2}$$

$s$ denoting the specific magnetism,
M denoting the magnetic moment,
$m$ denoting the mass of the magnets in mgs.,
$\varphi$ denoting half the angle of deflection of the magnet,
T denoting the horizontal intensity of the earth's magnetism,
$r$ denoting the distance between the center of the magnets and the mirror in mm.,

*Horse-shoe magnet made by Funckler; portative force, 50 kg.

$l$ denoting the distance between the poles of the magnets in millimeters.

In all cases the *specific magnetism*, i. e., the magnetic moment divided by the mass of the magnet, is given, instead of the magnetic moment, so as to allow a comparison of the results obtained with magnets of different dimensions.

The value of the horizontal intensity for one point in the laboratory being known from a recent absolute determination by Professor Kohlrausch, its value for the position of the magnetometer was obtained by relative determinations.

As the results to be obtained did not possess sufficient quantitative importance to warrant an experimental determination of the distance between the poles in the case of each magnet, 0·85 of the length of the magnets was used as approximation for the quantity ($l$).

The torsion-ratio of the fiber holding the mirror was determined as 0·00027 and not taken into consideration in the calculation of the results.

## Experiments.

### 8. *Experiments with Iron.*

Set I.* Iron. Length=90 mm.

| No. | Condition. | Diameter. | Deflection in scale divisions. | Specific Magnetism. |
|---|---|---|---|---|
| 1 | Natural | 1·70mm | 22·0mm | 161 |
| 2 | Hammered | 1·71 | 27·9 | 208 |
| 3 | Stretched | 1·60 | 31·7 | 276 |
| 4 | Stretched | 1·61 | 30·8 | 253 |

* Not specially softened.

Magnets 3 and 4 were hardened by stretching, one end being held in a vice.

Set II. Iron. Length=100mm. Diameter=0·94mm.

| No. | Number of holes. | Deflection in scale divisions. | Specific magnetism. |
|---|---|---|---|
| 1 | 0 | 16·8mm | 341 |
| 2 | 1 | 25·2 | 490 |
| 3 | 2 | 26·6 | 489 |
| 4 | 3 | 26·3 | 492 |
| 5 | 4 | 28·1 | 525 |
| 6 | 5 | 25·6 | 491 |
| 7 | 6 | 27·6 | 526 |
| 8 | 6 | 29·8 | 557 |

These wires were hardened by "pulling" them through the number of holes designated in the second column, by the method more fully described under "Hardening." (See 4, above.)

SET III. IRON. LENGTH 100mm.* DIAMETER 1·67mm.

| No. | Stretching weight. | Deflection in scale divisions. | Specific magnetism. |
|---|---|---|---|
| 1 | 0 kg | 25·2 | 164 |
| 2 | 0 | 24·6 | 160 |
| 3 | 10 | 26·4 | 173 |
| 4 | 25 | 25·0 | 165 |
| 5 | 35 | 30·8 | 204 |
| 6 | 45 | 30·3 | 201 |
| 7 | 55 | 31·9 | 217 |
| 8 | 60 | 32·5 | 230 |
| 9 | 65 | 33·3 | 241 |
| 10 | 65 | 35·4 | 275 |

* The decrease of the diameter from No. 1 to No. 10 was about two per cent of the diameter of No. 1.

These wires were hardened by subjecting them to the action of a stretching force in the apparatus made by Perreaux for determining the "breaking weight" of wires.

Wire No. 1, of Set III, being subsequently hardened by "hammering," the increase in length due to the same being cut off, had after magnetization a specific magnetism of 195.

Wire No. 2, of Set III, having been bent several times and remagnetized, had a specific magnetism of 189.

Comparing I, II and III, we find in each set the smallest value of the specific magnetism in the case of the softest wire and a gradual increase of the same with the hardening, in set III the increase amounting to 70 per cent. The increase of the specific magnetism seems at times somewhat irregular; this however is easily explainable by the remarks made under the head of "Hardening."

Experiments made with a magnet of cast iron (length 102mm. diameter 7mm.) also gave an increase of the specific magnetism with the hardness, the hardening being brought about by gentle hammering.

9. *Experiments with Steel.*—In the experiments with steel a difficulty presented itself, which though also present with iron was far less annoying there, namely the fact that the different wires were not homogeneous. This was noticeable not only from the fact that wires, in as far as possible the same physical condition, could be magnetized to very different extents, but also in that their "breaking weights" differed widely. On the other hand, however, pieces cut from the same wire gave results comparable with each other.

In the following experiments a piece of each wire used was left soft for the sake of comparison.

SET IV. "ENGLISH SILVER STEEL." LENGTH 100mm. THREE WIRES.

| | | Diameter. | Deflection. | Specific mag. |
|---|---|---|---|---|
| No. 1 | *a.* Broken by a weight of 125 kgs. | 1·48mm | 51·9 | 452 |
| | *b.* Soft | 1·56 | 85·6 | 685 |
| No. 2 | *a.* Subjected to a stretching weight of 60 kgs. | 1·51 | 59·2 | 499 |
| | *b.* Soft | 1·54 | 72·2 | 580 |
| No. 3 | *a.* Subjected to a stretching weight of 30 kgs. | 1·51 | 76·5 | 621 |
| | *b.* Broken by a weight of 77 kgs. | 1·52 | 46·0 | 379 |
| No. 1 | *b.* Hammered } remagnetized { | | 65·5 | 524 |
| No. 2 | *b.* Hammered } remagnetized { | | 61·1 | 480 |

SET V.* STEEL. LENGTH 90mm.

| Wire. | Stretching weight in kg. | Diameter. | Deflection. | Specific magnetism. |
|---|---|---|---|---|
| II a | 0 | 1·28 | 61·4 | 781 |
| I a | 0 | 1·28 | 60·0 | 756 |
| III a | 0 | 1·28 | 60·1 | 769 |
| I b | 20 | 1·27 | 61·0 | 776 |
| II b | 30 | 1·29 | 61·1 | 773 |
| I c | 50 | 1·28 | 61·1 | 775 |
| III b | 55 | 1·27 | 60·2 | 774 |
| III c | 60 | 1·28 | 55·2 | 708 |
| III d | 65 | 1·26 | 48·4 | 623 |
| II c | 70 | 1·29 | 50·1 | 637 |
| I d | 75 (brach) | 1·29 | 43·7 | 556 |

* Not specially softened.

These wires were hardened as in "Set III, iron."

Comparing the results obtained with steel (sets IV and V) we find the reverse of what we saw in the case of iron, namely, that the greatest specific magnetism occurs with the softest wires.

Many experiments with both steel and iron similar to those already given were made, but as nothing was obtained from them not contained in the above they are here omitted.

10. *Influence of the ratio of the length to the thickness on the specific magnetism.*—Later results obtained with steel, though in fact corroborating the earlier experiments, seemed at first to contradict them. Hitherto I had observed in all cases with steel a decrease of the capacity to retain magnetism with the hardening; a steel bar however, having a length of 100mm. and a diameter of 7mm., gave the reverse result, its specific magnetism when soft being 100, after hardening and remagnetization 133. The possibility that the bar was iron was refuted by the hardness it assumed on being heated and suddenly cooled. Experiments were then made with bars of "English Silver Steel," from Crooks Bros., the dimensions being the same as those of the above-mentioned magnet; also in this case an increase of the specific magnetism with the hardening was observed.

Thus was proven that the increase of the magnetism in the one case and the decrease in the other did not lie in the different quality of the steel employed.

It will be observed, however, that the dimensions of the magnets used in these later experiments were very different from those of the magnets used earlier, when the magnetism was found to decrease with the hardening; in the former case the ratio of the length to the thickness being 14·3, in the latter case in the neighborhood of 65.

To ascertain whether this caused the apparently contradictory results obtained, a magnet was made of "English Silver Steel," the length being so chosen as to obtain a magnet with about the same value of $\frac{L}{D}$ as in the case of those magnets, which had shown an increase of the specific magnetism with the hardening.

The constants of the magnet were: length = 21·0mm., diameter = 1·54mm., $\frac{L}{D} = 13{\cdot}6$. The magnet showed a 30 per cent larger specific magnetism in the hard than in the soft condition.

Thus the apparently contradictory results with steel seemed to be due to the different values of the ratio $\frac{L}{D}$.

The following sets of experiments, VI, VII and VIII, were made to test this conclusion more fully.

SET VI. "ENGLISH SILVER STEEL."

The wires designated by (b) were hardened by a stretching weight of 70kgs.

| Wire. | Length. | $\frac{L}{D}$ | Deflection. | Specific magnetism. |
|---|---|---|---|---|
| 1 b | 21·0mm | 13·7 | 10·9 | 80 |
| 1 a | 21·0 | 14·3 | 13·3 | 102 |
| 2 b | 40·0 | 26·0 | 50·0 | 190 |
| 2 a | 40·0 | 26·7 | 62·2 | 247 |
| 3 b | 60·0 | 39·0 | 124·0 | 309 |
| 3 a | 60·0 | 40·8 | 124·1 | 338 |
| 4 b | 120·0 | 80·0 | 600·1 | 742 |
| 4 a | 120·0 | 78·4 | 428·7 | 522 |

SET VII. FROM ONE WIRE OF "ENGLISH SILVER STEEL."

1b, 2b, 3b were hammered to obtain 1a, 2a, 3a.

| Wire. | Length. | $\frac{L}{D}$ | Deflection. | Specific magnetism. |
|---|---|---|---|---|
| 1 b | 31·1mm | 20·1 | 31·8 | 162 |
| 1 a | 31·3 | 20·1 | 38·5 | 186 |
| 2 b | 60·0 | 38·9 | 175·2 | 454 |
| 2 a | 61·0 | 39·1 | 176·4 | 456 |
| 3 b | 100·0 | 64·9 | 463·7 | 706 |
| 3 a | 101·0 | 65·4 | 371·9 | 566 |

SET VIII. FROM ONE WIRE OF "ENGLISH SILVER STEEL."

The wires were hardened as in set VII.

| Wire. | Length.* | $\frac{L}{D}$ | Deflection. | Specific magnetism. |
|---|---|---|---|---|
| 1 b | 27·0mm | 22·5 | 18·0 | 164 |
| 1 a | | | 19·8 | 180 |
| 2 b | 48·5 | 40·4 | 92·3 | 480 |
| 2 a | | | 93·0 | 484 |
| 3 b | 70·3 | 58·6 | 217·0 | 756 |
| 3 a | | | 173·8 | 604 |

* By mistake the increase in length due to the hammering was not measured.

The results of VI, VII and VIII, are represented graphically in fig. 1, p. 193.

From these results we see that a cylindrical magnet, magnetized to saturation, is able to retain more or less magnetism when soft than when hard, according to whether the quotient of its length by its diameter is greater or less than some value ($a_0$).

Furthermore it is evident that the specific magnetism is a continuous function of the quotient $\frac{L}{D}$.

Both of the foregoing laws have already been proven for heat-hardened magnets.*

No further experiments were made to ascertain from what the value of $\frac{L}{D}$ where the curves cross ($a_0$) might depend; Ruths found ($a_0$) to vary between 30 and 40, while in the three cases given here it varies but little from 41.

With iron no crossing of the curves of the hard and soft magnets was observed; it is probable, however, that at greater values of $\left(\frac{L}{D}\right)$ the curves do cross, and I hope at an early opportunity to study this portion of the subject more fully.

11. *Effect of heating the hardened wires.* — The question might well be asked if, when mechanically hardened wires are softened by heating, the increase or decrease in the magnetic moment, which was coincident with the hardening, disappears. Experiments to answer this were made by softening wires, the magnetic moment of which when hard had been determined, and then remagnetizing them; the specific magnetism was found to change in each case in the direction which would be expected from the experiments given in the foregoing pages, and the magnets were capable of having their moments increased or decreased, as the case might be, by a second hardening.

* Chas. Ruths, Ueber den Magnetismus weicher Eisencylinder, Dortmund, 1876.

12. Before leaving this part of the subject the result of some experiments should be stated, which were made to ascertain what care was necessary to be taken to prevent a loss of magnetism while the magnets were being adjusted, etc. A large loss of magnetism was observed in all cases when the magnets were subjected to any sudden jarring; so that, as may be seen from the following table, great care had to be exercised between the magnetization and the determination of the magnetic moment.

| | Wire. | Falling. | Loss of original magnetism. |
|---|---|---|---|
| 1 | Steel, soft | 1·5m | 30 per cent. |
| 2 | " mechanically hard | 2·0 | 44 |
| | | 3·0 | 57 |
| 3 | " soft | 3·0 | 55 |
| 4 | " mechanically hard | 2·0 | 52 |
| 5 | Iron, " " | 2·0 | 84 |
| 6 | " " " | 3·0 | 84 |
| 7 | " soft | 2·0 | 83 |
| 8 | " " | 2·0 | 97 |
| 9 | Steel, heat-hardened | 3·0 | 6 |
| 10 | " " " | 3·0 | 4 |

As is well known the heat-hardening does much to render a magnet less sensitive to jarring, etc.; it was not discoverable, from the experiments made, that the mechanical hardening produces even in a small degree a similar effect.

## II.—Experiments with unsaturated Magnets.

13. *Apparatus.*—The apparatus was arranged as is usual in cases where the temporary magnetic moment is to be determined by the deflection of a magnetometer needle; the method having been so often described by others,* it would seem unnecessary to enter into any minute description here.

The effect of the magnetizing helix on the magnetometer was counterbalanced by a second one, the helices being placed, the one to the north, the other to the south of the instrument. The course of the current was as follows: from the battery through the two coils and a variable resistance to a key, and finally through a tangent-compass back to the battery.

By means of a commutator, the direction of the current in the tangent-compass could be reversed.

The constants of the magnetizing helix were as follows:

| | |
|---|---|
| Length | 223mm |
| Internal radius | 19 |
| External radius | 52 |
| Number of windings per layer | 55 |
| Number of layers | 10 |

As an accurate and at the same time convenient method of adjusting the magnets, a glass tube, with an internal diameter

* Compare Ruths, Ueber den Magnetismus weicher Eisencylinder. Dortmund, 1876.

somewhat larger than that of the magnets, was held firmly by corks in the axis of the coil, and the magnets pushed into position by a glass rod.

The tangent-compass was made with a single ring of copper, having a mean diameter of $404^{mm}$.

The compass needle, being but $20^{mm}$ long, was provided with a glass pointer; the scale, which was divided into degrees, was cut on mirror glass.

The order of the observations was as follows: (1.) reading of the magnetometer with the circuit open; (2.) with the circuit closed; (3.) with the circuit closed and the magnet in the coil; (4.) the deflection of the tangent-compass was then determined [commutated]; (5.) and lastly the magnetometer reading was taken with the circuit open and the magnet in the coil.

The difference between the readings (3) and (2) gives the deflection due to the temporary magnetism; that between 5 and 1, the deflection due to the permanent magnetism.

14. *Calculation of the Experiments.*—The calculation resolves itself into (a) that of the magnetic intensity in the coil, and (b) that of the resulting temporary and permanent magnetism.

(a.) *Intensity of the magnetic force.*—This resolves itself again into two, the calculation of the intensity of the current and that of the constant for the magnetic working of the coil.

The intensity of the current was calculated by the formula: $i = A \operatorname{tg} \varphi$. The reduction factor $\left(A = \frac{Tr}{2\pi n}\right)$ of the tangent-compass to the absolute system was calculated 62·7.

The correction to the above formula, due to the cross-section of the windings and the length of the needle lay within the errors of observation, and was therefore not considered.

(b.) *Intensity of the magnetic field in the coil.*

The formula,

$$(I) \qquad X_x = \frac{i\pi n}{a}\left[\frac{a-x}{\sqrt{(a-x)^2+r^2}} + \frac{a+x}{\sqrt{(a+x)^2+r^2}}\right]$$

gives the magnetic effect of a coil, of the length 2a, the radius $r$ and $n$ windings traversed by a current of intensity $i$, on a point situated in the axis of the helix at a distance from its center.

To obtain the mean intensity of the field for a bar, with the length 2b, and with a cross-section so small that we may consider the bar as lying wholly in the axis, we divide formula (I) by $2b$ and after multiplying by $dx$, integrate between the limits $x=-b$ and $x=+b$.

We thus obtain,

$$(II) \qquad X_{2b} = \frac{1}{2b}\int_{x=-b}^{x=b} X_x\,dx = \frac{\pi n i}{ab}\left[\{(a+b)^2+r^2\}^{\frac{1}{2}} - \{(a-b)^2+r^2\}^{\frac{1}{2}}\right]$$

Finally to obtain the effect of the ($c$) layers of windings, the external and internal radii being respectively $r'$ and $r'$. we can multiply formula (II) by $\frac{c}{r''-r'}dr$ and integrate the product with respect to $r$, from $r=r'$ to $r=r''$. We thus obtain,

$$\text{(III)*}\quad \frac{X}{i}=\tfrac{1}{2}\frac{\pi n}{ab}\cdot\frac{c}{r''-r'}\Big[(a+b)^2\cdot\log\frac{r''+\sqrt{(a+b)^2+r''^2}}{r'+\sqrt{(a+b)^2+r'^2}}$$
$$+(a-b)^2\log\frac{r'+\sqrt{(a-b^2)+r'^2}}{r''+\sqrt{(a-b)^2+r''^2}}+r''\{\sqrt{(a+b)^2+r''^2}$$
$$-\sqrt{(a-b)^2+r''^2}\}+r'\{\sqrt{(a-b)^2+r'^2}-\sqrt{(a+b)^2+r'^2}\}\Big]$$

The value of $\left(\frac{X}{i}\right)$ calculated by (III) for the magnetizing helix used was found to be 29·23, for $2b=100$.†

(c.) *Calculation of specific magnetism.*—In these experiments the magnets were situated so that the prolongation of the undeflected magnetometer needle was perpendicular to them at their middle point, and hence the specific magnetism is to be calculated by the following formula:

$$s=\frac{M}{m}=\left[\frac{r^3T\operatorname{tg}\varphi}{1-\frac{3}{8}\frac{l^2}{r^2}}\right]\cdot\frac{1}{m}\cdot\text{mm}^{\frac{5}{2}}\text{mg}^{-\frac{1}{2}}\cdot\sec^{-1}$$

The various quantities have the same meanings as in the corresponding formula in part I.

## 15. *Experiments.*

"English Silver Steel." Wire 1 a. Hard. Subjected to a stretching weight of 81 kgs. Length 100mm. $\frac{\text{Length}}{\text{Diameter}}=69\cdot0$.

| Perm. mag. | | Temp. mag. | | | |
|---|---|---|---|---|---|
| Deflection. | Sp. mag. | Deflection. | Sp. mag. | Tangent-compass Deflection. | Magnetic force. |
| 0·1 | 3·75 | 0·3 | 11·2 | 0°·90 | 28·8 |
| 0·8 | 29·9 | 2·4 | 89·9 | 2·55 | 81·6 |
| 1·4 | 52·4 | 4·6 | 172 | 3·55 | 114 |
| 2·8 | 105 | 6·2 | 232 | 4·50 | 144 |
| 4·8 | 180 | 10·1 | 378 | 6·45 | 207 |
| 7·8 | 292 | 16·7 | 625 | 10·65 | 345 |
| 9·8 | 376 | 26·8 | 1004 | 19·55 | 651 |
| 10·9 | 408 | 32·0 | 1202 | 31·45 | 1125 |
| 11·0 | 412 | 33·6 | 1258 | 37·55 | 1410 |

* Compare W. Weber, "Elektrodynamische Massbestimmungen, insbesondere über Diamagnetismus," p. 547. Ruths, Magnetismus weicher Eisencylinder, p. 7.

† All the magnets used were 100mm long.

WIRE 1 b. SOFT. LENGTH=100mm. $\frac{\text{LENGTH}}{\text{DIAMETER}}=67{\cdot}6$.

| Perm. mag. | | Temp. mag. | | Tangent-compass Deflection. | Magnetic force. |
|---|---|---|---|---|---|
| Deflection. | Sp. mag. | Deflection. | Sp. mag. | | |
| 0·1 | 3·66 | 1·6 | 58·6 | 1°·30 | 41·6 |
| 1·8 | 65·9 | 4·1 | 150 | 2·45 | 78·4 |
| 3·6 | 132 | 7·1 | 260 | 2·80 | 89·7 |
| 8·0 | 293 | 13·2 | 483 | 4·45 | 143 |
| 11·9 | 436 | 19·3 | 706 | 6·40 | 206 |
| 14·0 | 512 | 23·1 | 845 | 8·45 | 272 |
| 18·8 | 688 | 30·8 | 1127 | 18·20 | 603 |
| 20·0 | 732 | 34·4 | 1259 | 28·70 | 1004 |
| 20·1 | 736 | 35·4 | 1295 | 35·90 | 1327 |

"ENGLISH SILVER STEEL." WIRE 2 a. HARD (HAMMERED). LENGTH=100mm. $\frac{\text{LENGTH}}{\text{DIAMETER}}=69{\cdot}9$.

| Perm. mag. | | Temp. mag. | | Tangent-compass Deflection. | Magnetic force. |
|---|---|---|---|---|---|
| Deflection. | Sp. mag. | Deflection. | Sp. mag. | | |
| 0·7 | 24·3 | 2·2 | 76·4 | 2°·15 | 68·8 |
| 2·0 | 69·5 | 5·0 | 174 | 3·45 | 110 |
| 3·5 | 122 | 8·4 | 292 | 4·20 | 135 |
| 7·3 | 254 | 14·4 | 500 | 6·00 | 193 |
| 10·0 | 347 | 21·2 | 736 | 9·80 | 317 |
| 11·9 | 413 | 25·7 | 893 | 13·50 | 440 |
| 14·0 | 486 | 31·8 | 1105 | 23·45 | 795 |
| 15·5 | 538 | 35·9 | 1247 | 40·30 | 1554 |

WIRE 2 b. SOFT. LENGTH=100mm. $\frac{\text{LENGTH}}{\text{DIAMETER}}=70{\cdot}9$.

| Perm. mag. | | Temp. mag. | | Tangent-compass Deflection. | Magnetic force. |
|---|---|---|---|---|---|
| Deflection. | Sp. mag. | Deflection. | Sp. mag. | | |
| 0·2 | 7·10 | 1·9 | 67·5 | 1°·40 | 43·8 |
| 1·1 | 39·1 | 4·1 | 146 | 2·30 | 73·6 |
| 3·7 | 131 | 7·8 | 277 | 3·00 | 96·1 |
| 7·3 | 259 | 13·0 | 462 | 4·35 | 140 |
| 10·1 | 359 | 17·1 | 607 | 5·30 | 170 |
| 13·8 | 490 | 23·7 | 842 | 8·40 | 271 |
| 16·5 | 586 | 28·7 | 1020 | 12·95 | 422 |
| 18·2 | 647 | 32·3 | 1143 | 18·05 | 597 |
| 19·9 | 707 | 35·5 | 1260 | 28·05 | 977 |
| 19·8 | 703 | 36·9 | 1310 | 35·70 | 1318 |

"ENGLISH SILVER STEEL." BAR 3 a. HARD (HAMMERED). LENGTH=101·5mm. $\frac{\text{LENGTH}}{\text{DIAMETER}}=14{\cdot}5$.

| Perm. mag. | | Tangent-compass deflection. | Magnetic force. |
|---|---|---|---|
| Deflection. | Sp. mag. | | |
| 1·0 | 1·61 | 1°·35 | 43·2 |
| 3·5 | 5·62 | 3·10 | 99·3 |
| 5·1 | 8·19 | 4·45 | 143 |
| 9·3 | 13·9 | 6·90 | 222 |
| 13·1 | 21·0 | 9·60 | 310 |
| 20·3 | 32·6 | 14·20 | 464 |
| 33·3 | 53·5 | 33·50 | 1103 |
| 35·5 | 57·0 | 37·65 | 1416 |

"English Silver Steel." Bar 3 b. Soft. Length=100mm. $\frac{\text{Length}}{\text{Diameter}}=14{\cdot}3$.

| Perm. mag. | | Tangent-compass deflection. | Magnetic force. |
|---|---|---|---|
| Deflection. | Sp. mag. | | |
| 3·2 | 5·10 | 2°·25 | 72·0 |
| 4·9 | 7·81 | 3·30 | 106 |
| 6·9 | 11·0 | 4·30 | 138 |
| 9·0 | 14·3 | 5·50 | 177 |
| 12·6 | 20·1 | 8·50 | 274 |
| 18·0 | 28·7 | 12·85 | 418 |
| 23·1 | 36·8 | 17·85 | 590 |
| 32·2 | 51·3 | 31·90 | 1140 |
| 34·3 | 54·1 | 38·45 | 1450 |

Iron. Wire 4 a. Hard ("Pulled"). Length=100mm. $\frac{\text{Length}}{\text{Diameter}}=139$.

| Perm. mag. | | Temp. mag. | | Tangent-compass deflection. | Magnetic force. |
|---|---|---|---|---|---|
| Deflection. | Sp. mag. | Deflection. | Sp. mag. | | |
| 0 | 0·0 | 0·7 | 91·9 | 1°·85 | 59·1 |
| 0·2 | 26·3 | 1·6 | 110 | 2·10 | 67·2 |
| 4·1 | 539 | 5·9 | 775 | 4·20 | 135 |
| 5·1 | 670 | 7·2 | 946 | 5·40 | 173 |
| 5·9 | 775 | 9·2 | 1208 | 8·35 | 269 |
| 6·3 | 827 | 12·5 | 1642 | 18·10 | 599 |

Iron. Wire 4 b. Soft. Length=100mm. $\frac{\text{Length}}{\text{Diameter}}=139$.

| Perm. mag. | | Temp. mag. | | Tangent-compass deflection. | Magnetic force. |
|---|---|---|---|---|---|
| Deflection. | Sp. mag. | Deflection. | Sp. mag. | | |
| 1·8 | 245 | 2·8 | 380 | 1°·25 | 40·0 |
| 2·7 | 367 | 4·0 | 543 | 1·45 | 46·4 |
| 3·8 | 516 | 5·9 | 801 | 1·90 | 60·8 |
| 4·2 | 570 | 8·8 | 1195 | 4·15 | 133·0 |
| 4·3 | 584 | 9·9 | 1344 | 5·60 | 179·7 |
| 4·3 | 584 | 11·4 | 1548 | 13·60 | 443 |
| 4·3 | 584 | 11·8 | 1603 | 19·55 | 651 |

The results are graphically represented in figs. 2 and 3 on the following page.

16. *Conclusions.*—If we compare the curves (Fig. II), representing the temporary specific magnetism of steel and iron as dependent on the magnetizing force, we see, as was to be expected, that the mechanical hardening to some extent hinders the turning of the molecules by the magnetic force. From the curves (Fig. I), representing the permanent specific magnetism of steel we see, that, where the quotient $\left(\frac{L}{D}\right)$ is greater than $(a_0)$, the softer magnet has the advantage, without reference to the intensity of the magnetizing force. If on the other hand $\left(\frac{L}{D}\right)$ is less than $(a_0)$ (Fig. III), the softer magnet has the advantage up to a certain value of the magnetizing force, when the specific magnetism of the harder magnet overtakes that of the softer, and is ahead at the saturation point, as we saw in the first part of this article.

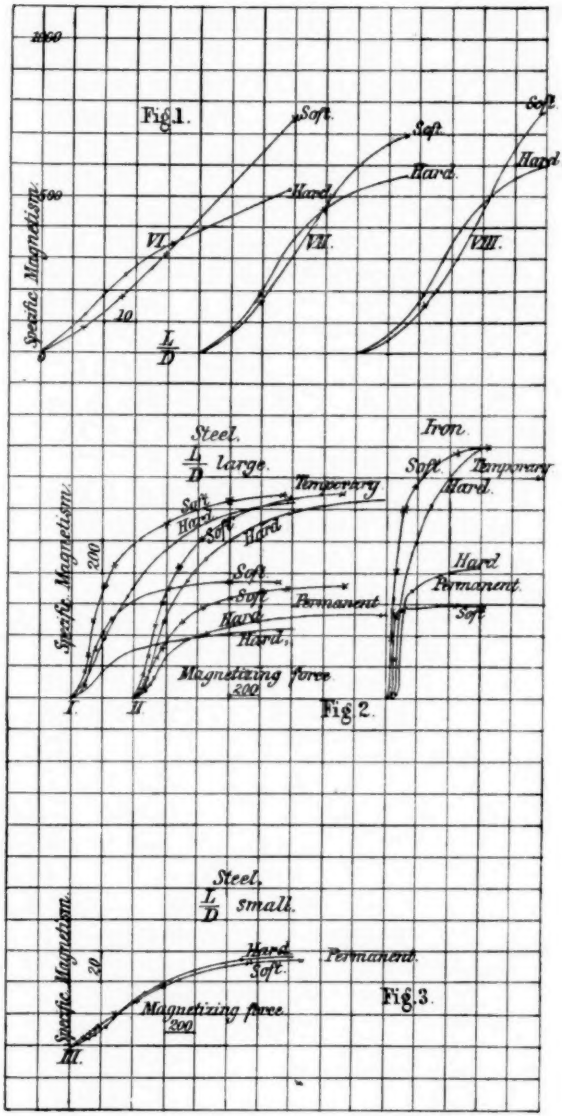


Fig. 1.
Specific Magnetism.
500
10
L/D
VI.
VII.
VIII.
Soft.
Hard.
Steel.
L/D large.
Temporary
Soft
Hard
Permanent
Specific Magnetism.
200
Magnetizing force
200
I.
II
Fig. 2.
Iron.
Soft.
Temporary
Hard.
Hard
Permanent.
Soft.
Steel.
L/D small.
Hard
Soft.
Permanent.
Specific Magnetism.
20
Magnetizing force
200
III.
Fig. 3.

The same holds for the permanent specific magnetism of iron,* as for steel where $\left(\frac{L}{D}\right)$ is less than $a_0$. These results are in entire accordance, qualitatively, with the results obtained by Ruths† and others with heat hardened magnets.

*Differences between the mechanical and heat hardening.*—We have thus seen that both mechanical and heat hardening bring about changes in steel and iron, which, for the most part, affect their magnetic properties similarly, and the question naturally arises whether there is any reason for believing the conditions caused by each to differ, other than in degree.

A comparison of their effects on some of the physical properties of steel would seem to require an affirmative answer.

Thus the specific resistance of steel has been shown to be very materially altered by the heat hardening, a change of 200 per cent taking place at times,‡ while the specific resistance of steel wires hardened by "pulling" is thereby altered, at the most, a few per cent.

Thus also, if we consider the change of specific gravity by hardening and that of the corresponding specific magnetism, we are led to believe the two conditions to be different; steel, if heat hardened, has the smallest specific gravity§ when hardest and the largest specific magnetism [pre-supposing $\frac{L}{D}$ small], so that the largest specific magnetism corresponds to the smallest value of the specific gravity; when steel is hardened by hammering, on the other hand, the specific magnetism $\left[\frac{L}{D}\text{small}\right]$ and specific gravity increase together, as I have repeatedly found by experiment.

It would seem also to follow from the foregoing that the magnetic moment is not dependent on the specific gravity, as at times has been supposed.‖

Physical Institute. University of Würzburg, Nov. 1, 1881.

*Compare remarks at end of paragraph 10.

†Chas. Ruths, Ueber den Magnetismus weicher Eisencylinder. Dortmund, 1876.

‡ Compare Strauhal and Barus, Ueber Anlassen des Stahles und Messung seines Härtezustandes, Wied. Ann., vol. xi, p. 976. 1880.

§Carl. Fromme, Wied. Ann., vol. viii, p. 352. 1879.

‖Compare the remarks of Ruths on this point, p. 48.

ART. XXII.—*The Deerfield Dyke and its Minerals;* by BEN. K. EMERSON, Professor of Geology in Amherst College.

*Description of the dyke.*—The most northern of the large dykes of diabase associated with the Connecticut River sandstone commences in Gill, and after running southwestwardly a short distance, swings round to the south and runs down the west side of the Connecticut through Greenfield and Deerfield, and turning eastward crosses the river and ends in Mt. Toby.

It has thus the elongated U-shape characteristic of the Triassic dykes of the basin, which appears on a scale so much larger in the Holyoke Range. It is worthy of note that the high western border of the valley corresponds in direction to both these dykes, being set back in Greenfield and Northampton so as in each case to present a reëntrant angle to the N.W. corner of the dykes with W.E. and W.S. sides parallel to the corresponding portions of the respective dykes. The dyke is about twenty miles long and at Cheapside, in the north part of Deerfield where the Deerfield River breaks through it, is about 30m. thick. The rock is intercalated in the red sandstone and dips eastward with it, but would seem to follow this direction only a little way before coming to the fissure through which it was erupted, as an artesian well sunk on their property in Turner's Falls by the Montague Paper Co. went down in sandstone 274m. below the level of the Turner's Falls dam, while immediately opposite on the west and separated only by the width of the river, about 200m., the trap is about 30m. above the dam, and dips toward the well with an angle of 32°.

*Fault at the mouth of Fall River.*—The best point for the study of this dyke, as indeed for the study of the Connecticut River sandstone in Massachusetts, is at Turner's Falls, and opposite this village at the mouth of Fall River, at the chlorophæite locality the dyke is beautifully faulted. It comes down from the north to the water's edge, and directly in continuation of it in the Connecticut is a sandstone island, while the dyke is offset ten rods to the westward on the other side of Fall River. The proof of the faulting is complete. The sandstones above and below agree bed for bed in all particulars and the outcrops are peculiarly good. This is the only fault in the sandstones which I have been able to prove with certainty.

The dyke rests to the west on coarse granitic sandstone which it has baked for an inch into a black hornstone and influenced for a foot. The diabase is compact in its lower part and amygdaloidal above, and the soft red shales which rest upon it are wholly unaltered—are never included in the trap—

but fold around all small protuberances in its upper surface as if it were a later deposit. This is shown in an almost unbroken outcrop a mile long opposite Turner's Falls, where the river has notched into the trap and exposed the junction. These facts can hardly be explained except by supposing the trap to have been poured out upon the lower sandstone, and to have been covered by the upper shales. The same state of things holds with regard to the great Holyoke dyke, and in addition the extensive tufa beds intercalated in the sandstones above the latter and described by President Hitchcock * can not but strongly reinforce this conclusion. I am aware that it has been suggested that the beds described by President Hitchcock as tufa beds have been explained as bands of the common sandstone indurated by steam escaping during the ejection of the lavas between the layers of the sandstone, but I have cut sections from the blocks of diabase enclosed in this stratum at the most accessible locality of it, the roadside below Smith's Ferry in Northampton and find it to be identical with that of the Holyoke range immediately north. The blocks are large, angular and abundant, and are mixed with granitic material and I cannot doubt that they have come from the erosion of the great dyke, which must thus antedate them.

Similar tufa beds are exposed above the amygdaloid of the dyke under discussion at the west and highest point of the outcrops on the Greenfield road. They are here of finer grain and closely resemble the Nassau Schalsteine.

*Lithology.*—The rock is a typical diabase, ranging from aphanitic varieties to those where the flat white feldspars are 2–4$^{mm}$ square, and from compact to very coarse amygdaloidal. The different varieties are of very uniform texture and always in an advanced stage of decomposition though appearing quite fresh; plagioclase apparently of two species; augite, magnetite and olivine are uniformly present. Apatite cannot be detected.

The common plagioclase, probably labradorite, is always by far the most abundant constituent, and the angle of extinction of its long rod-like crystals is commonly 12°. Several varieties of the rock are sub-porphyritic by the development of white spots made up of groups of stout crystals of a second triclinic feldspar apparently distinct from the first whose angle of extinction is 21°. Both feldspars are thoroughly decomposed commonly from the center, and sometimes show only aggregate polarization.

The augitic constituent has for the most part gone over into a mixture of green and brown chloritic minerals, here and there an exceptionally large crystal remains in whole or part

* Geology of Mass., 1841, p. 442.

intact. The olivine is often the freshest looking mineral in the slide except the magnetite.

The rock at the new cutting and southward is very fine grained, breaking with conchoidal fracture, dark gray and compact at the base of the dyke, and there distinguished by the abundance of the well-known feathery aggregations of the magnetite grains, while in the whole upper portion it is coarsely amygdaloidal, the amygdules filled commonly with diabantite, calcite, or both—when one penetrates below the deep layer of rusty scoriaceous rock from which all the secondary minerals have been removed,—and here the magnetite is never arranged in feathery groups. At the old cutting on the other side of the Deerfield river, a few rods north, the rock becomes more granular in texture, grayish and reddish varieties occur, sub-porphyritic, and abounding with flattened steam cavities filled now with diabantite which arranged in layers give the rock an indistinct fluidal structure. These varieties continue northward and are exposed in great force for nearly a mile of fresh cuttings, where the road from Greenfield to Turner's Falls crosses the dyke, and from the Suspension bridge, at the end of this road, along the river side for a mile north to the mouth of Fall River and beyond. Through all this area prehnite and the products of its decomposition occupy the amygdaloidal cavities in very great quantity accompanied everywhere by traces of copper minerals, in place of calcite and chalcedony which abound farther south. The most interesting variety is a very coarse one abundant on the Greenfield road, which contrasts pleasantly with the somber gray of the prevailing types. Broad white plates of the feldspar stand out upon a dark red background of decomposed augite, the whole sprinkled with the amygdules of prehnite and diabantite. That this coarse variety is younger than the greenish gray sub-porphyritic trap, is clear from a large slab from the middle of the slope on the Greenfield road, showing a contact of the two upon which the latter is cut off immediately and sharply and without change, while the former has a layer of deep red, very fine grained rock $15^{mm}$ wide adjacent to the contact plane. It seemed to me, however, to represent only a slight difference in age and to be probably a case of "schlieren" in the sense of E. Reyer.*

An exceptional rock occurs abundantly in bowlders on the south side of the Deerfield, but I have not met it on the north or in place. It is a clear, light gray rock, with roundish blotches of white, and it looks like a weathered leucitophyr. Under the microscope the blotches are seen to be made up of aggregated stout crystals of plagioclase, and the rest of the mass between, of rod-like plagioclase and magnetite with almost no

* Tschermak, Min. Mitth.

augite. The rare amygdules in this rock are filled with a fine silky radiated mineral, apparently an altered prehnite resting upon diabantite, or more rarely lined with glassy crystals of albite, with datolite, pyrite or globules of zinc blende.

*Historical.*—Already in 1818* President Hitchcock noticed several of the zeolitic minerals enumerated below, with a word in each case as to mode of occurrence, and mentions as localities one mile E. 2° 15′ S. from Deerfield Academy, and the copper veins opposite Turner's Falls. In 1826† he described a mineral from the mouth of Fall River near Turner's Falls as the chlorophæite of Macculloch. In the final report on the Geology of Massachusetts, pp. 203, 660, he enumerates the minerals there known without increasing the former list: barite, copper, malachite, chalcocite, chalcopyrite, chlorite, chlorophæite, calcite, prehnite, augite, quartz and varieties, selenite, chabazite, lincolnite.

A few years ago railroad cuttings on the north side of the Deerfield River at Cheapside exposed veins of massive datolite 3 to 4$^{cm}$ wide, which showed no distinct crystals and occurred without the minerals which commonly accompany it, excepting prehnite.

During the summer of 1880, a heavy cut was made through the corresponding portion of the dyke on the south side of the river for the extension of the Canal Railroad, and opened up veins carrying the usual trap minerals in great abundance and beauty. These veins run nearly vertically, with a thickness not above 10$^{cm}$, and were exposed to a depth of above 18$^{mm}$. I propose to describe the minerals in the order of their occurrence in the veins and to discuss at some length their paragenesis and the crystallography of several of them.

Diabantite.—The chloritic mineral, so uniformly and abundantly disseminated in the diabase of the valley, was entered in the catalogue of the State collection by Dr. Hitchcock as foliated chlorite, Turner's Falls, and a paler pulverulent variety, as earthy chlorite, Springfield. A third mineral, intimately associated with these follows them in the collection under the name chlorophocite, a misprint for chlorophæite, Gill. The latter is for the sake of symmetry made to follow prehnite, it being a product of the decomposition of the latter mineral. That the former mineral is chemically identical with that analyzed by Hawes and named diabantite by him, is extremely probable in view of their identity in all physical and especially optical properties, and of the monotonous similarity of the many diabase dykes of the Connecticut basin, in which both occur. That the mineral is distinct from delessite, as the word is used by Zirkel, Rosenbusch and Heddle, is much less certain.

* This Journal, i, 115, 116. † This Journal, x, 393.

It is the earliest product of the decomposition of the diabase, and proceeded doubtless from the alteration of the augite. In one case I found a mass having the shape of an augite crystal filled with magnetite toward the outside and polarizing as a single individual but possessing the bright green color and the strong dichroism of diabantite. It is disseminated in comparatively small amount through the mass of the rock between the feldspar crystals and thus in the place of the augite, much more abundantly in the steam cavities and shrinkage cracks with which the rock abounds. It generally coated the empty amygdaloidal cavities first with a quite thick ($\frac{1}{2}$–1$^{mm}$) foliated-radiated layer with minute, delicate botryoidal surface. Several such layers sometimes followed each other, and then the center became filled with a confused granular mass of the same material, the whole making a very pleasing effect under the microscope with its bright green color and striking dichroism. Under crossed Nicols this central granular portion often assumes a deep chlorite green studded with bright colorless spots (calcite?) and maintains this color through a whole revolution of the object, the bright spots being alternately extinguished. Sometimes, in the gray mottled diabase, a layer of magnetite or coal grains was interposed between the layers of diabantite, and rarely large distinct crystals of magnetite appear wholly surrounded (in section) by diabantite, and in one case a fine, large feather of magnetite projected into the diabantite. The long feldspar crystals, also, which border the cavity, often project freely into it and are then perfectly and more complexly terminated than when in the mass. The diabantite folds around and does not penetrate them. Often the center of the cavity is filled with calcite, impregnated with diabantite, so as to produce a pegmatitic appearance on cleavage faces, or with finely fibrous prehnite and this also is for a greater or less distance toward the center blackened by the abundance of the diabantite which it has enclosed.

On the other hand where over the botryoidal layer of diabantite there appear quartz, datolite, natrolite, sphalerite or other sulphurets, they are entirely free from this impregnation. In the broad mineral-bearing fissures, the diabantite often so impregnates layers of scaly or fibrous prehnite 1–5$^{mm}$ thick over considerable surfaces that a black or blackish-green mass results, often abundantly slickensided, which so resembles a very fine grained scaly or fibrous schist that I supposed it to be formed by the pulverizing of the trap by friction and the cementing of the powder by prehnite, until the microscope made known its true character.

Farther north on the dyke opposite Turner's Falls the large flattened cavities are lined with a botryoidal layer 1$^{mm}$ thick,

of black-green diabantite with crystals of chalcopyrite, blende and albite upon it. The interior is very often filled with a dark olive-green, fine-granular mixture of crystals of diabantite which can be shaken out of the cavity as a fine powder, each grain of which appears, under the microscope, as beautifully vermicular as the helminth of the older rocks.

The paragenesis of the mineral is thus quite definitely fixed. It was the first product of the decomposition of the diabase and its formation ceased not very long after calcite and prehnite began to be deposited in the cavities and fissures. As the formation of the latter minerals was attended by quite energetic decomposition of the trap, the formation of the diabantite occurring still earlier may well have been promoted by the increased chemical activity of the waters during the cooling of the trap after its solidification. The mineral seems to me plainly of secondary formation, and I can see no good ground for thinking that it was formed and deposited where we find it during the rise of the lava through the sandstones. The cavities flattened and fluidally arranged in the lower part of the mass with well terminated feldspars projecting into them, and growing very abundant, and graduating into long vertically placed tubes in the upper portions, have been certainly formed, by steam, and cannot have been filled till after solidification of the rock. This is much more certainly the case with the broad fissures which extend across the whole dyke, which seem for a time to have furnished a passage-way for boracic acid springs, and in which the diabantite must have been formed much as were the calcite and prehnite which it has impregnated. The filling of the cavities also with several concentric and botryoidal layers sometimes separated by calcite would indicate slow deposition from water.

The great amount of protoxide of iron in the mineral does not seem to me to need for its explanation the assumption that it is an original constituent of the rock. The waters brought up in the lava, on becoming liquid, or the waters which reached the bed after percolating through the bituminous sandstones of the valley may have been deprived of oxygen and able to exert strong solvent activity, without peroxidizing the iron of the augite. In discussing a mineral, which seems to be identical with our diabantite and which forms the first coating of the amygdules of the phillipsite-bearing feldspar-basalt of Salesl, von Zepharovich* derives the same from sphærosiderite, the radiated and concentric structure and the botryoidal surface resembling in miniature that common in the carbonate. A cellular structure and traces of rhombohedral forms were also observed. I have seen here no traces of any such crystal forms.

*Zeitsch. Kryst., v, 98, 1880.

The cellular or excavated structure occurs frequently and can be produced in fresh specimens by acid, by the removal of calcite. The occurrence of the mineral in fresh prehnite and calcite would militate against its being here a pseudomorph after siderite.

*Products of the decomposition of diabantite.*—From its great content of ferrous oxide the mineral is very prone to decomposition and in sections cut near the weathered surface of the rock its color has become red-brown, its strong dichroism is gone, and it shows only the faintest aggregate polarization. Sometimes a cavity shows the exterior changed and brown, the interior bright green, with sharp lines of demarkation. In the large amygdules masses of gold or bronze-yellow, sometimes light straw-yellow, can be obtained, which exfoliate voluminously under the blowpipe and then by a sharp explosion throw off the exfoliated portion, and begin the operation anew. It is a *diabantite-vermiculite.* At the end of this series of changes only a small quantity of limonite remains.

When a slide of the diabase is treated with hydrochloric acid both the fresh and the altered diabantite are decomposed and white silica remains behind in plates having still the shape and arrangement of the original mineral. This is also the case with the vermiculite out of the primary rocks in Pelham.

Similar amygdules occur in the compact diabase having a white color or being in part still green and dichroic, and having exactly the arrangement of the diabantite. These are, I have no doubt, silica, and have been produced by some natural process analogous to the artificial one employed above. The white portions show marked aggregate polarization in white and black but without bright colors.

ALBITE.—In the cavities in the amygdaloid from the shores opposite Turner's Falls, which are often only partly filled with the vermiferous diabantite (vide p. 199) and out of which the latter may be shaken as a deep green powder, there occur minute crystals loosely seated upon the diabantite, or in the powder shaken out from the cavities and scarcely attached at all. They are ·005 to ·01mm. in diameter, transparent, perfectly fresh crystals, twinned in accordance with the albite law. They are combinations of the form $i\text{-}\breve{\imath}$, *O*, $i\text{-}\bar{3}'$, $i\text{-}\bar{3}$, *I'*, *I*, $i\text{-}\bar{\imath}$, $2\text{-}\bar{\imath}$, flattened by the large development of $i\text{-}\breve{\imath}$, and much elongated in the direction of the axis $\breve{a}$, by one end of which they are uniformly attached. Examined with the polarizing microscope the line of extinction makes with the edge $O \wedge i\text{-}\breve{\imath}$ an angle of +4° to +4° 30′ on the face *O*. When lying upon the face $i\text{-}\breve{\imath}$ the minute twins gave varying results. The first result indicates that the crystals are albite according to the determin-

ations of Max Schuster,* the second is explained by the multiple twinning of the crystals.

When placed in a delicately graduated Thoulet's fluid, so prepared that orthoclase will rest near the surface and labradorite near the bottom, the crystals found the exact level of fragments of transparent albite from Haddam, sp. gr. 2·62, and remained attached to them as if they were so delicately freed from outward attraction that they gravitated toward each other. Some of the crystals having diabantite adherent to them sank to the level of quartz, sp. gr. 2·64, but all were separated by a broad interval from the other triclinic feldspars. The position of these crystals is interesting from a paragenetic point of view. The cavities are tapestried on all sides by the diabantite and the albites rest, often very loosely, upon it, and while forming projected freely into the interior as is shown by their glassy clearness and perfection of form and polish. The last of the diabantite seems sometimes to fill the cavities into which the albites project, but this could not be made certain. As the albite probably demands elevated temperature and increased pressure for its formation, the diabantite upon which it rests must be assigned to the time following immediately upon the consolidation of the lava, while its heat still intensified the chemical activity of the water it contained.

(To be continued.)

---

ART. XVIII.—*On the Löss and associated Deposits of Des Moines;* by W. J. MCGEE, of Farley, Iowa, and R. ELLSWORTH CALL, of Des Moines, Iowa.

[Read before the Iowa Academy of Sciences, May 31, 1882.]

THE occurrence of typical löss at Des Moines has already been noted by F. M. Witter,† the junior author of this paper,‡ and a number of local geologists. Late in 1881 the junior author observed that in certain sections that deposit appeared to be overlain by a bowlder-bearing stratum; and the present communication embraces the results of a series of investigations suggested by this observation.

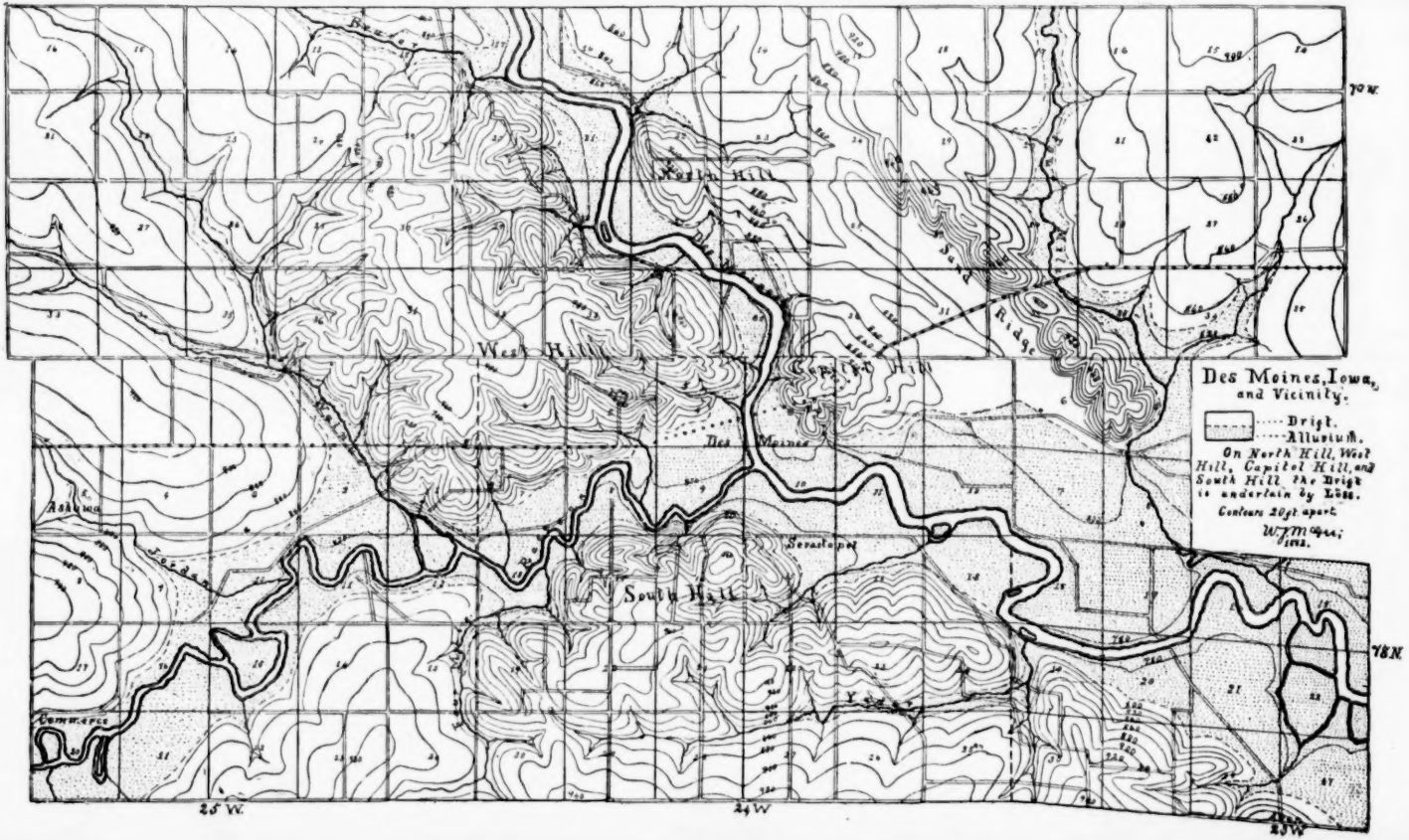
In its leading geographical features the accompanying map is a copy of a part of the map of Polk county in Andreas's Atlas;§ though a few minor details have been added from observation.

* Tsch. Min. Mitth., iii, 117, 1880.

† Paper read before the Muscatine Academy of Sciences, Muscatine Tribune, Feb. 10, 1879.

‡ American Naturalist, xv, Oct., 1881, p. 782; loc. cit., xvi, May 1882, p. 369 *et seqq.*

§ A. T. Andreas' Illustrated Historical Atlas of the State of Iowa, 1875, p. 181.


Des Moines, Iowa, and Vicinity.
Drift.
Alluvium.
On North Hill, West Hill, Capitol Hill, and South Hill the Drift is underlain by Lias.
Contours 20ft apart.
Wm Gee; 1892.
North Hill
West Hill
Capitol Hill
South Hill
Des Moines
Sand Ridge
Ashburn
Commerce
78 N.
25 W.
24 W.
23 W.

The cenological* and hypsometrical features were made out during the progress of the present investigation. In the projection of the contours, as well as in the construction of the profile, use was made of all measured railway, roadway and street elevations within the area shown. These data were supplemented by observations and estimates made on the ground and from the dome of the State capitol; from which point nearly the whole area is distinctly visible. Neither the contours nor the profile are, accordingly, strictly accurate, though in a general way they are reliable.

It may be explained that in this latitude in Iowa the drift is everywhere superficially modified to some extent; the upper portion being fine, homogeneous, free from bowlders and pebbles but sometimes containing calcareous nodules, and löss-like in structure, aspect and topographical configuration, but graduating imperceptibly into unmodified glacial drift within a few feet below the surface. The term "drift" is herein applied only to the *upper till*, i. e., to the glacial deposit overlying the *forest bed*. The *lower till* has not been seen within the area shown.

The cartography and the preparation of the cuts are the work of the senior author; the determination of, and remarks on, the fossils enumerated are by the junior author; while the field work was jointly performed.

## I.

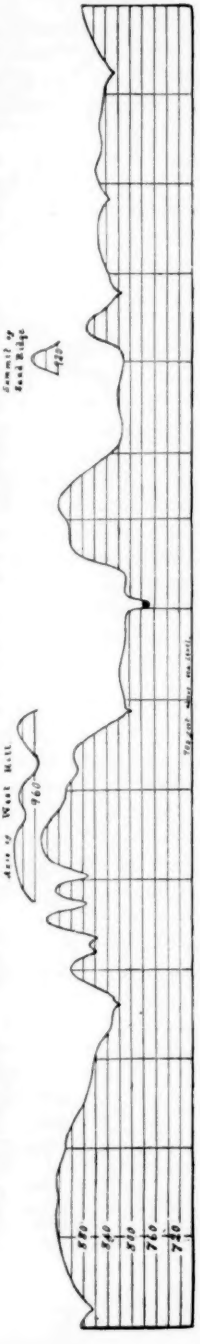
East of Four Mile creek lies a gently undulating plain of drift slightly modified superficially, but exhibiting the characteristic drift topography. On the west rises a prominent ridge capped with löss at its southern end but exposing drift in ravines and road-cuttings, formed of fine stratified sand to a depth of at least fifteen feet in its medial portion, and exposing only drift with rounded and worn erratics cropping out on its summit to the northward. It probably has a nucleus of Carboniferous strata, overlain throughout by drift; the sand and löss being superimposed upon the drift stratum. This ridge is apparently analogous to the åsar of eastern Iowa. West of it lies a uniform plain formed of drift with little superficial modification, so low and level as to be almost without natural drainage. As a broad trough, this plain connects the angles in the valley of the Des Moines river above and below the confluence of the Raccoon in so marked a manner as to have given rise to the general (but erroneous) popular impression that it is an

* We prefer the term cenology to "surface geology," "superficial geology," "glacial geology," "post-tertiary geology," or any of the numerous compound names that have been applied to the branch of geology treating of terrestrial, fluviatile and lacustral deposits.

abandoned channel of that river. From its western border rise two insulated plateaus of characteristic löss topography but with numerous erratic bowlders scattered over their summits; the southernmost, known as "Capitol Hill," being the higher. Both have nuclei of Carboniferous rocks forming perhaps three-fourths of their altitudes; and both are manifestly separated from the high land to the westward by the erosion of the Des Moines valley.

West and north of the Des Moines and Raccoon rivers lies the most elevated plateau of this region; two-thirds of its height being formed of Carboniferous strata. It is deeply scolloped on all sides by steep-sided labyrinthine ravines such as characterize löss areas; but interiorly it undulates gently in quaquaversal slopes forming mounds and basins manifestly not due to Post-quaternary erosion, while over all its higher portions numerous erratic bowlders, sometimes smoothed and striated, lie on or near the surface. Northwestward the surface declines gently, and the plateau merges into the drift-plain covering most of the State. Northward and westward Beaver creek and Walnut creek wash its base, and sharply separate the rolling and broken highland from the gently undulating drift-plain beyond. Over this plain, as over the plain east of Four Mile creek, the drift is somewhat modified superficially. Still farther westward rises a smaller insulated plateau of löss-like topography, and outside of the area mapped are similar plateaus, all extending N.N.W. from the Raccoon valley in a series of lobes each of which resembles somewhat the ridge east of Des Moines.

South of the two rivers and east of the westernmost Four Mile creek, the topographical configuration and the superficial deposits are the same, in the immediate vicinity of the river bluffs, as on the central plateau above the confluence of the rivers; the Carboniferous strata forming perhaps three-fourths of the height of the bluffs. The altitude here is rather less




Profile along dotted line. Fig. 2.

than on the central plateau, from which this region has manifestly been separated by the erosion of the valley of the Raccoon river. Southward from the river bluffs the bowlder-bearing deposit merges into the superficially modified drift extending to the Three Rivers, and the general altitude gradually diminishes. Ascending the Raccoon the elevated range of bluffs rather suddenly dies away at the westernmost Four Mile creek; and above are the more gentle slopes characteristic of drift areas —the slope here being toward, instead of away from the river.

Summing up the predominant physiographical features of the region under consideration, it appears (1) that the Des Moines and Raccoon rivers have avoided uniform plains and have corraded their channels through the most elevated plateau of sedimentary strata existing within many miles; and (2) that there has been an unusual accumulation of Quaternary deposits over this plateau about the confluence of the rivers.

These features conform to laws which the senior author has found to obtain over much of eastern Iowa; for not only do the North Maquoketa, South Maquoketa, Buffalo, Wapsipinnicon, Cedar and Iowa rivers avoid low-lying plains and seek elevated plateaus and ridges of both sedimentary rocks and quaternary deposits in many localities, but the general course of all these rivers is at right angles to the mean slope of the surface which they drain.

## II.

The following are a few only of the sections examined. Each is located on the map, and numbered as in the text. The altitude is to the top of the section. The probable error in altitude refers to the city datum of low water at the confluence of the Des Moines and Raccoon rivers, which is assumed to be 780 feet above sea level.* In the lists of fossils, species not now living in the vicinity are marked with an asterisk.

### Section 1.

S.W. cor. Walnut and E. 9th Sts.—Altitude, 860 ± 2 feet.

1.—Löss, light drab, fine, homogeneous, without distinct stratification, with vertical structure and cleavage, and with two or three irregular zones yielding a profuse calcareous efflorescence. It contains tolerably abundant löss-kindchen,† tubelets (or slender, irregularly ramifying calcareous tubes), and characteristic löss fossils disseminated throughout. Ten feet.

* Gannett (Lists of Elevations, 4th ed., 1877, p. 70) gives 779 feet as the low-water altitude of the Des Moines river at Des Moines.

† Over 2800 löss-kindchen, mainly from sections 1, 2 and 9, were recently examined and in part figured and described, by the junior author.—American Naturalist, xvi, May, 1882, p. 373. Plate V.

2.—An undulating ferruginous band an inch or two broad, constituting a false line of separation, sloping with, but less rapidly than the surface, most distinct in downward modulations, where there are unusual numbers of löss-kindchen immediately above, and of cylindrical ferruginous concretions immediately below it.

3.—Löss, ashen or bluish, containing löss-kindchen, tubelets and fossils identical with those of No. 1, as well as cylindrical concretions. Below it becomes silty, pulverulent, and obscurely laminated parallel with the base; and fossils, tubelets and löss-kindchen disappear within one or two feet from its lower limit. Four feet.

4.—Vermilion-red clay, as in the following section. One foot.

This section, which is the typical löss-section of this part of the State, is exposed in a street cutting near the summit of Capitol Hill. The depth of the cutting is about ten feet, but the slope of the street is such as to expose over fifteen feet in depth of strata. The ferruginous band marks the limit of secular oxidation, and is not structural, though it generally follows the obscure lines of stratification which occasionally occur in this deposit wherever it is found in Iowa. In no respect, indeed, is the löss of this section distinguishable from that of typical exposures along the Missouri river, save perhaps in the smaller size of its fossils. It has now stood in an absolutely vertical wall for nearly two years, and has formed but a very slight talus. The fauna is identical with that of the following section.

SECTION 2.

E. SIDE E. 9TH ST. BET. WALNUT ST. AND COURT AV.—ALT. 858 ± 2 FT.

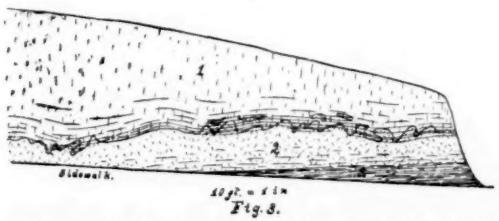



Fig. 3.

1.—Löss, ashen or light drab, compact, vertically cleft, and containing löss-kindchen, tubelets, and rare fossils above, obscurely laminated, pulverulent, silty, unfossiliferous and with minute ochreous specks below. The laminæ follow the major undulations of the irregular base, but in part pass through the minor projecting knobs of the subjacent member; and a few lenticular or irregular masses of this member occur intercalated within the löss. The principal vertical cleavage planes of the löss pass through its basal portion and into No. 2.

2.—Vermilion-red clay, tenacious when wet, friable and granular when dry, massive below and obscurely laminated above, containing a few small exfoliated pebbles of shale and more abundant minute reniform nodules of impure limonite, and exhibiting occasional dark-red ochreous stains.

3.—Arenaceous Carboniferous shale, gray, blue, yellowish and drab in color.

The löss in this section is continuous with that in the last, and is identical with it in every particular except that the false line of separation is here absent. The red clay is the product of decomposition *in situ* (preglacial) of the subjacent shale. Though the junction between the löss and clay is quite distinct, owing to the difference in color, there is some interstratification of the two deposits. The löss here yielded the following fossils:

| | |
|---|---|
| *Succinea obliqua* Sar. | *Mesodon clausa* Say. |
| *Limnophysa humilis* Say. | *Patula striatella* Anth. |
| **Helicina occulta* Say. | * *Vallonia pulchella* Müll. |

SECTION 3.

N. SIDE COURT AV. BET. E. 10TH AND E. 11TH STS.—ALT. 880 ± 3 FT.

1.—Light reddish-buff unstratified drift clay containing numerous rounded, subangular and angular pebbles, mainly erratic, up to six inches in diameter, bits of coal and a lenticular mass of Carboniferous clay three feet long and six inches thick. Seven feet.

2.—The same, obscurely and irregularly stratified, interstratified with bands of löss, and sometimes contorted, containing löss-kindchen, tubelets and fossils (often fragmentary), in the drift strata in direct association with pebbles, as well as in the bands of löss. Five feet.

3.—Löss, similar to and continuous with that observed in sections 1 and 2, abounding in löss-kindchen, tubelets and fossils; the following species being represented:

| | |
|---|---|
| *Succinea obliqua* Sar. | *Mesodon clausa* Say. |
| *Limnophysa humilis* Say. | *Stenotrema monodon* Rackett. |
| **Helicina occulta* Say. | *Hyalina arborea* Say. |

Workmen were engaged in making this excavation at the time of examination; and it was accordingly perfectly fresh and unaltered. The interstratification described was perfectly distinct. The fauna here was found to be identical with, but less abundant than, that of the undisturbed löss, which was exposed for only about a foot at the base of the section. The löss here is confidently coördinated with that of sections 1 and 2 on paleontological, lithological and stratigraphical grounds; for not only are faunas and physical characters identical, but

actual continuity was traced in the street excavations. The next following section is on the opposite side of the street, and the principal members were unquestionably continuous with those in this section before the street was graded. It was not fresh when examined, and the transition from drift to löss was obscure.

### Section 4.

S. Side Court Av. bet. E. 10th and E. 11th Sts.—Alt. 882 ± 3 ft.

1.—Reddish-yellow sandy clay containing numerous rounded, subangular and angular pebbles up to twelve inches in diameter, associated toward the base with löss-kindchen and fossils. About eight feet.

2.—Löss, light buff, somewhat sandy and pebbly above, containing numerous löss-kindchen, tubelets and fossils. Six feet. The following are some of the species here found:

*Succinea obliqua* Sar.
*Succinea avara* Say.
**Helicina occulta* Say.
*Limnophysa humilis* Say.
*Limnophysa desidiosa* Say.
**Pupa muscorum* Linn.
*Pupa pentadon* (?) Say.
*Hyalina arborea* Say.
**Vallonia pulchella* Müll.
**Patula strigosa* Gould.
*Patula striatella* Anth.
*Patula alternata* Say.
*Strobila labyrinthica* Say.
*Mesodon clausa* Say.

A like sequence was observed in a number of other sections in the vicinity; and drift, sometimes modified superficially, but containing many erratic bowlders up to three feet in diameter on or near the surface, was found to prevail over the entire summit of Capitol Hill. The proportion of pebbles in this drift is less, however, than is usual in this latitude; the clay presents a somewhat löss-like aspect, contains calcareous concretions and yields a calcareous efflorescence; and the topography assumed is essentially identical with that of löss areas.

The plateau north of Capitol Hill (generally known as North Hill) is similarly capped with drift of the aspect described; and in like manner löss crops out along the bluffs overlooking the Des Moines river. A general section here by the junior author* exhibits typical löss reposing on drift on both sides of the river. That on the east yielded the following fossils:

*Succinea obliqua* Sar.
*Limnophysa humilis* Say.
*Limnophysa desidiosa* Say.
**Helicina occulta* Say.
*Patula alternata* Say.
*Patula striatella* Anth.
**Patula strigosa* (?) Gould.
*Pupa fallax* Say.
*Pupa armifera* Say.
*Pupa pentadon* Say.
*Hyalina arborea* Say.
**Vallonia pulchella* Müll.
*Stenotrema monodon* Rack.
*Helicodiscus lineatus* Say.
*Strobila labyrinthica* Say.
Undetermined fish spine.

* American Naturalist, xv, p. 783, Oct., 1881.

### Section 5.

N. side Center St. bet. W. 7th and W. 8th Sts.—Alt. 877 ± 2 ft.

1.—Brownish-yellow drift clay containing rounded, sub-angular and angular pebbles, mainly erratic, up to ten inches in diameter, and a few irregular, tortuous and discontinuous lines of stratification, together with löss-kindchen and tubelets, below; where it passes by both interstratification and insensible gradation into löss. Above it is finer, less pebbly and more homogeneous.

2.—Löss, light buff, with a few irregular and tortuous lines of clay, sand or gravel intercalated above, but undisturbed and in all respects typical below, where it contains abundant tubelets, rather few and small löss-kindchen, and rare fossils of the following species:

*Succinea obliqua* Sar.
*Succinea avara* Say.
*Limnophysa humilis* Say.
**Helicina occulta* Say.

The cutting (which was not fresh at the time of examination) is nine feet deep; its summit being approximately level for half a block. The line of junction of 1 and 2 slopes west, exposing only the löss at the middle of the block, and only drift at the northeast corner of Center and Seventh streets. The drift has manifestly been removed by erosion toward the east. Within half a block to the north the superficially modified drift has been removed to a depth of two feet from a considerable area, exposing some dozen crystalline bowlders up to three feet in diameter; one, of green stone, being polished. Over this area, as in the löss of the section, there is a profuse calcareous efflorescence.

### Section 6.

Cistern on N.W. Cor. Park and Jefferson Sts.—Altitude 970 ± 12 feet.

In this excavation, fourteen feet deep, only drift is exposed. It is rather fine, clean and homogeneous for the first three feet, then abounds in pebbles of stone with a few of sand for eight feet, and toward the base exposes mainly sand, pebbles associated with small stone pebbles, löss-kindchen, tubelets, and rare fossils; but these phases graduate into each other—there being not the slightest trace of stratification from bottom to top. The stone pebbles vary in size from ten inches downward, are mainly erratic, though a few, including bits of coal, are local, are generally round or sub-angular, and are occasionally smoothed and polished. One, two inches in diameter, is finely striated on both sides; the two sets of striæ on one side diverging by 30° and 60° respectively from the single set on the other side. To another, a calcareous concretion is attached. Most of the sand pebbles (of which a score or more appear in the sides and bot-

tom of the cistern) are rounded, and vary from one to six inches in diameter. They are sometimes composed of fine sand, either massive or laminated, again of uniformly coarse sand or fine gravel, and at other times of a mixture of all. The two largest are lenticular in cross-section, each about two feet long and eight inches thick; one consisting of fine laminated sand, and the other of coarse ferruginous gravel. None of these pebbles, except the last mentioned, are at all cemented. About eight feet from the surface is a distinct dark-brown ferruginous band one or two inches thick, above which the drift is brownish-yellow and free from cylindrical ferruginous concretions. Below it is quite blue and abounds in the ferruginous concretions for three feet, then irregularly mottled and with rare concretions for two feet, while for the last part it is again brownish-yellow and without the concretions. The fossils occur only near the base associated with smoothed pebbles, sand-pebbles, löss-kindchen, and tubelets, and are mainly fragmentary. The following species, in addition to many indeterminate fragments, were observed:—

*Succinea obliqua* Sar.
*Succinea avara* Say.
*Limnophysa humilis* Say.
*Patula striatella* Anth.

The excavation was examined while in progress, and immediately after completion. Erratic bowlders up to five feet in diameter were exposed in contiguous street cuttings. Throughout the drift presents a löss-like aspect in color, constitution and structure. On exposure it hardens exteriorly and yields a calcareous efflorescence.

### Section 7.

S.W. Cor. Washington St. and Cottage Grove Av.—Altitude 975 ± 5 feet.

1.—Brownish-yellow drift clay containing rather numerous erratic, and a few local pebbles and bowlders. Fifteen (?) feet.

2.—Löss, light buff, containing löss-kindchen, tubelets, and the following fossils:

*Succinea obliqua* Say.
*Limnophysa humilis* Say.
*Pupa*, sp. undt., probably *P. pentadon*

10 (?) ft.

3.—Irregularly stratified gravel, sand and pebbly drift clay, brownish-yellow. Two feet.

The section was based on the materials thrown from a well just completed and walled, the sequence being determined by the arrangement, and the thickness of each member estimated from the amount of such material in the annular heap surrounding the well. It supplements the adjacent section 6 in showing that on this plateau the drift is unquestionably underlain

by löss, which in turn reposes upon another drift stratum. Careful search for fossils was not made; a number of individuals of the shells enumerated being found in a single clod.

### Section 8.

Road cutting near S.E. Cor. S.W. S.E. 1, 78 N., 25 W.—Altitude 950 ± 20 feet.

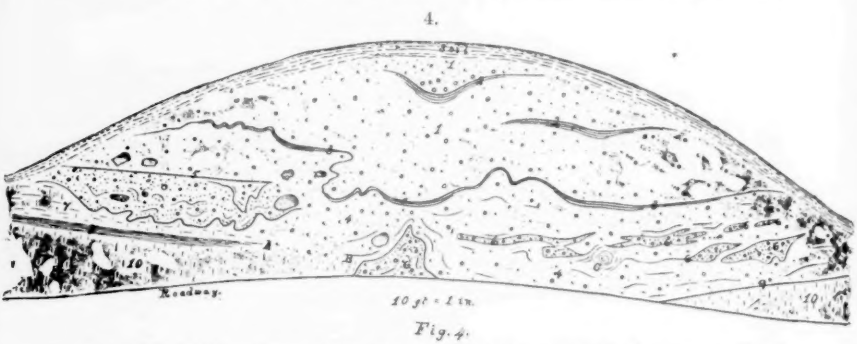



*Fig. 4.*

1.—Brownish-yellow drift clay, without stratification except as indicated, containing a few sub-angular and rounded pebbles and bowlders, mainly erratic, gradually becoming fine, clean and homogeneous above. Toward the base it yielded a few large löss-kindchen, a *Succinea obliqua*, a *Stenotrema monodon*, and several fragments of shells.

2.—Irregular and tortuous bands of unusual löss-like aspect.

3.—An irregularly undulating ochreous band separating the brownish-yellow from the mottled and bluish division of the drift. Obscure toward the extremities, and most distinct medially.

4.—Bluish, brownish-blue and mottled drift clay, identical with number 1 except in color, containing bowlders as indicated up to fifteen inches in diameter, rounded sand and gravel bowlders up to ten inches, many erratic pebbles of which several are polished, one striated, and one cemented to a calcareous concretion, a few local pebbles including bits of coal, a spherical mass of löss fifteen inches in diameter, a few cylindrical ferruginous concretions, numerous löss-kindchen and tubelets, and a similar fauna to that of number 10, but with most of the shells crushed and fragmentary. Below it is contorted, is obscurely interstratified with bands of löss, and contains intercalated layers and masses of stratified or laminated sand and gravel in which the laminæ are broken and contorted. From A to B, it graduates insensibly into number 10.

5.—A well-marked line of division.

6.—Brown and yellow sand and gravel, generally coarse, stratified and irregularly contorted. Unfossiliferous.

7.—Identical with base of No. 3.
8.—A band of fine, massive, homogeneous marl.
9.—A distinct line of separation, somewhat ferruginous.
10.—Löss, bluish for one-half foot from the summit, light drab to brownish-buff below, yielding a calcareous efflorescence, exhibiting typical structure and constitution in all respects, containing cylindrical ferruginous concretions (most abundant in the blue portion), löss-kindchen and tubelets, and affording the following fauna:

*Succinea obliqua* Sar.
*Succinea avara* Say.
*Limnophysa desidiosa* Say.
*Limnophysa humilis* Say.
**Helicina occulta* Say.
*Hyalina arborea* Say.
*Patula striatella* Anth.
**Patula strigosa* Gould.
* *Vallonia pulchella* Müll.
*Stenotrema monodon* Rack.
*Helicodiscus lineatus* Say.
*Mesodon clausa* Say.
*Mesodon multilineata* Say.
*Pupa corticaria* Say.
**Pupa muscorum* Linn.
*Pupa armifera* Say.
*Strobila labyrinthica* Say.

Though the section was not fresh at the time of examination, it was little obscured by weathering or talus and exhibited the details very clearly. A syenite bowlder nearly three feet in diameter was partially imbedded in the drift within a few feet of the section.

### Section 9.

Railway Cutting on Fair Ground siding in N.W.S.W. (?) 7, 78 N., 26 W.—Alt. 875 ± 15 ft.

1.—Brownish-yellow drift clay containing erratic pebbles and bowlders up to four feet, yielding *Succinea obliqua* and *Limnophysa humilis* toward the base, where it passes into number 2 by both interstratification and insensible gradation. About fifteen feet.
2.—Typical löss, containing ferruginous concretions, löss-kindchen, tubelets, and the following fossils:

*Succinea obliqua* Sar.
*Succinea avara* Say.
*Limnophysa humilis* Say.
*Hyalina arborea* Say.
*Hyalina minuscula* Bin.
**Patula strigosa* Gould.
*Patula striatella* Anth.
*Patula alternata* Say.
**Pupa muscorum* Linn.
*Pupa corticaria* Say.
**Helicina occulta* Say.
* *Vallonia pulchella* Müll.
*Helicodiscus lineatus* Say.
*Mesodon clausa* Say.
*Mesodon multilineata* Say.
**Mesodon thyroides* (?) Say.
*Strobila labyrinthica* Say.
*Conulus fulvus* Drap.
*Vertigo ovata* Say.
*Carychium exiguum* Say.

The section was much obscured by a heavy talus and by debris from near the surface at the time of examination.

Like phenomena were observed in a number of sections not here described; and over the entire plateau lying between the

Des Moines and Raccoon rivers, just as on that constituting Capitol Hill, a fine, compact, superficially modified drift clay, yielding a calcareous efflorescence on exposed surfaces, and bearing erratic bowlders sometimes four or five feet in diameter, was found to prevail. The finer upper portion, which, notwithstanding its comparative freedom from smaller pebbles, contains the largest bowlders, has been removed from a total area of several acres (to be employed in the manufacture of brick), leaving abundant bowlders lying on the surface. One of these, of green stone, two or three feet in greatest diameter, was found to be deeply striated longitudinally on two parallel sides: and another, of like material and equal size, was finely polished on one side. The topographical configuration is in general similar to that of löss areas; but the erosion has thus far been mainly peripheral.

### Section 10.

Brick-clay Pit S. of cor. Jefferson St. and Indianola Av.—Alt. 845 ± 6 ft.

1.—Light brown, coarse, friable loam, free from pebbles, massive, but graduating into number 2. Three feet.
2.—Light brown and gray stratified sand in slightly sinuous but generally horizontal bands one-third inch thick, each massive. Eight feet.
3.—Löss, blue and ashen-blue, obscurely laminated horizontally, with rather rare löss-kindchen, abundant tubelets and cylindrical ferruginous concretions, and very rare fossils; only fragments of *Succinea* and *Pupa* appearing on hasty examination. Four feet.
4.—Arenaceous shale of the Coal Measures, partially decomposed at the summit.

The two uppermost members form a portion of a nearly destroyed terrace. A very few pebbles and two or three bowlders one or two feet in diameter, probably derived from them, lie about. A distinct ferruginous band apparently separates numbers 2 and 3; but in reality there is some interstratification about the line of junction. Immediately below this band cylindrical ferruginous concretions occur in greatest abundance. The löss is slightly silty in aspect and friable in texture, as toward the base in sections 1 and 2.

A sequence, substantially identical with that noted on Capitol Hill and on the central plateau, was observed in two or three sections near the summit of the bluff; and in S.E.N.W. 21, 78 N., 24 W., where the surface is formed of drift, a cellar is reported to have entered a löss-like deposit. The topography is labyrinthine, and the drift is as löss-like and calcareous as on the north side of the river; but no bowlders more than two feet in diameter were here seen.

The desirability of tracing the superior and inferior surfaces of the löss toward the periphery of the once continuous plateau on which it is found, and to their termini, was fully realized; but it was found impracticable to do so. Drift materials were however found beneath the löss in section 7; and this is known to be the normal sequence of these deposits. Moreover, the superincumbent drift-sheet has been traced uninterruptedly, in different directions, to localities in which no löss occurs beneath it. The stratigraphical relations of the löss of this vicinity must, accordingly, be as shown in the accompanying ideal section, in which erosion is not taken into account.

5.

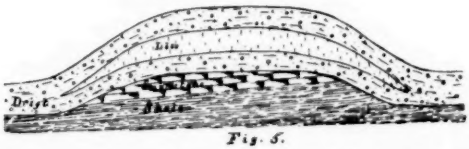



Fig. 5.

Recapitulating the salient stratigraphical features of the region under consideration, it appears, (1) That the löss is confined to elevated plateaus; (2) That its upper portion is broken up, contorted and interstratified and commingled with glacial drift; and (3) That the whole is overlain by unmodified glacial drift.

The first of these features is consonant with the phenomena observed by the senior author in northeastern Iowa, where the löss similarly affects the highest summits and divides; but the others are unknown elsewhere.

## III.

The accompanying synoptical faunal tables will afford the means of determining the relative abundance and variety of molluscan life during the formation of the deposits studied as compared with the present. The twenty-four species listed in table I are unequally distributed among fifteen subgenera, and these again unequally among five families. The *Helicidæ*, *Pupadæ* and *Helicinidæ** are terrestrial groups, the *Limnæidæ* a fresh-water family, while the remaining one, together with the subgenus *Succinea* of the *Helicidæ* may be quite properly considered semi-aquatic.† Table II contains nearly twice the number of forms found in table I, the exact number being

* These last are not *Pulmonata*, however.

† In the case of *Succinea* this statement should not be taken too literally. Though it prefers extremely damp or moist stations it is often found far removed from such localities and in even very dry situations. Nevertheless its optimum habitat appears to be a moist one.

## *Synoptical Table.* I.—*Löss Fossils.*

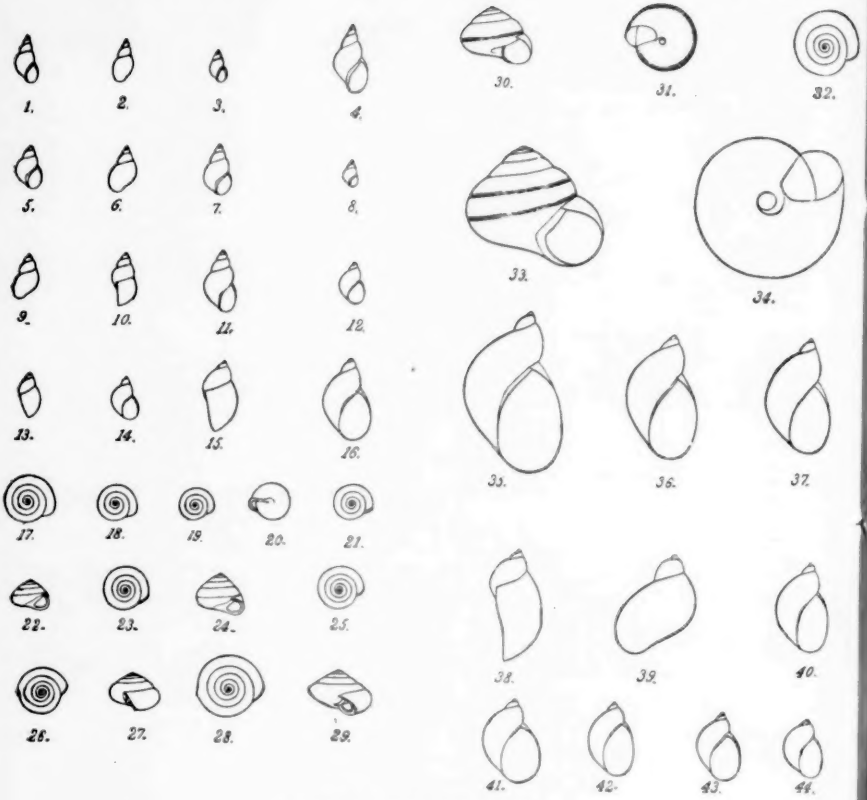
(Species now extinct in this locality in *italics.*) (Number of specimens measured in parenthesis.)

| Families. | Sub-Genera. | Species. | Number in each sub-genus | Number in each Family. | Measurements. | Normal measurements. Given in descriptions. |
|---|---|---|---|---|---|---|
| Limnæidæ. | Limnophysa | humilis. | | | Largest $\frac{6}{10}$ inch.<br>Smallest $\frac{1}{10}$ + inch.(19) | $\frac{7}{10}$ inch. |
| | | desidiosa. | 2 | 2 | Largest $\frac{2}{4}\frac{3}{8}$ inch.<br>Smallest $\frac{6}{48}$ inch. (63) | $\frac{7}{10}$ inch. |
| Helicidæ. | Succinea | obliqua. | | | Largest 19mm.<br>Smallest 6mm. (200+)<br>Average 13½mm. | 18mm. |
| | | avara. | 2 | | Largest 5·5mm.<br>Smallest 2mm. (37)<br>Average 4·54mm. | Extreme length 6mm. |
| | Mesodon | clausa. | | | Greater diam. 7mm.<br>Height 6⅜mm. (2) | Greater diam. 11½mm.<br>Height 11½mm |
| | | multilineata. | | | Greater diam. 19·5mm.<br>Height 13·5mm. (13) | Greater diam. 23mm.<br>Height 14mm. |
| | | *thyroides.* (?) | 3 | | A single specimen, much *below* normal if identification be correct. | Greater diam. 22mm.<br>Height 13mm. |
| | Stenotrema | monodon. | 1 | | Greater diam. 8mm.<br>Height 6mm. (11) | Greater diam. 11mm.<br>Height 6mm. |
| | Patula | alternata. | | | Greater diam. 16mm.<br>Height 9·5mm. (6) | Greater diam. 21mm.<br>Height 10mm. |
| | | *strigosa.* | | | Greater diam. of largest specimen 19mm.<br>Height 15mm. (59)<br>Average diam. 16mm. | Greater diam. 21mm.<br>Height 10mm. |
| | | striatella. | 3 | | Greater diam. 5·5mm.<br>Height 3mm. (109) | Greater diam. 6mm.<br>Height 3mm. |
| | Strobila | labyrinthica. | 1 | | Slightly less than normal. (6) | Greater diam. 2½mm.<br>Height 1⅝mm. |
| | Conulus | fulvus. | 1 | | Greater diam. 4mm.<br>Height 2·8mm. (15) | Greater diam. 4mm.<br>Height 3mm. |
| | Helicodiscus | lineatus. | 1 | | Greater diam. of largest specimen 3·175mm.(20)<br>Average diam. 3·4mm. | Greater diam. 3½mm.<br>Height 1½mm. |
| | *Vallonia* | *pulchella.* | 1 | | Average of 50 specimens about equal to the *normal.* | Greater diam. 3mm.<br>Height 1½mm. |
| | Hyalina | arborea. | | | Slightly less than normal. (44)<br>Average *height* 2·8mm. | Greater diam. 5mm.<br>Height 2⅛mm. |
| | | minuscula. | 2 | 15 | No measurements.<br>Specimens all imperfect. | Greater diam. 2½mm.<br>Height 1mm. |
| Pupadæ. | Pupilla | pentodon. | | | See context. | Length 2mm.<br>Diam. 1mm. |
| | | *muscorum.* | 2 | | See context. | Length 4mm.<br>Breadth 1½mm. |
| | Leucochila | armifera. | | | See context. | Length 4⅛mm.<br>Diam. 2⅜mm. |
| | | corticaria. | 2 | | See context. | Length 2½mm.<br>Diam. 1mm. |
| | Isthmia | ovata. | 1 | 5 | See context. | Length 3mm.<br>Diam. 1½mm. |
| Helicinidæ. | *Oligyra* | *occulta.* | 1 | 1 | Diam. 6½mm.<br>Height 5·25mm. (350) | Diam. 9mm.<br>Height 6mm. |
| Auriculidæ. | Carychium | exiguum. | 1 | 1 | See context. | 1⅜mm. |
| 5 | 15 | 24 | 24 | 24 | | |

*Synoptical Table.* II.—*Recent Mollusca (Gasteropoda).*

| Families. | Sub-Genera. | Species. | Number in each sub-genus. | Number in each Family. | Distribution.* |
|---|---|---|---|---|---|
| Limnæidæ. | Limnophysa | humilis. | | | Interior & Eastern provinces. |
| | | reflexa. | | | Int. prov., northern half. |
| | | desidiosa. | 3 | | Int. & Eastern prov. |
| | Physa | heterostropha | | | Int. & Eastern prov. |
| | | gyrina. | 2 | | Int., northern half. |
| | Helisoma | trivolvis. | | | Int. & Eastern prov, |
| | | bicarinatus. | 2 | | North-Int. & Eastern prov. |
| | Gyraulus | parvus. | 1 | | Int. & Eastern prov. |
| | Menetus | exacutus. | 1 | 9 | North- & East-Int. & East'n. |
| Ancylinæ. | Ancylus | tardus. | | | Int. & Eastern prov. |
| | | parallelus. | 2 | 2 | Int. & Eastern prov. |
| Viviparidæ. | Campeloma | subsolidum. | 1 | 1 | North-Int. prov. |
| Valvatidæ. | Valvata | tricarinata. | 1 | 1 | North-Int. & Eastern prov. |
| Rissoidæ. | Bythinella | obtusa. | 1 | | North-Int & Eastern prov. |
| | Amnicola | limosa. | | | North-Int. & Eastern prov. |
| | | parva. | | | Int of Eastern prov. |
| | | porata. | 3 | | North-Int. & Eastern prov. |
| | Somatogyrus | subglobosus. | 1 | 5 | North-Int. & Eastern prov. |
| Helicidæ. | Hyalina | arborea. | | | All of North America. |
| | | minuscula. | 2 | | West-Eastern, Central, & Pacific. Also extra-limital. |
| | Patula | striatella. | | | Northern prov. & Pacific. |
| | | alternata. | 2 | | All over Eastern prov. |
| | Succinea | obliqua. | | | Northern & Int. Region of Eastern prov. |
| | | avara. | | | Eastern & Central prov. |
| | | ovalis. | 3 | | Northern & Int. Regions of Eastern prov. |
| | Helicodiscus | lineatus. | 1 | | Eastern, Central, & Pacific prov. |
| | Ferussacia | subcylindrica. | 1 | | Northern Region of Eastern prov. Circumpolar. |
| | Stenotrema | monodon. | | | Eastern prov. |
| | | hirsutum. | 2 | | Northern-Eastern prov. |
| | Macrocyclis | concava. | 1 | | Eastern prov. |
| | Strobila | labyrinthica. | 1 | | Eastern prov. |
| | Conulus | fulvus. | 1 | | Circumpolar. All over Eastern prov. |
| | Mesodon | albolabris. | | | Eastern prov. |
| | | profunda. | | | Int. Region of Eastern prov. |
| | | clausa. | | | Int Region of Eastern prov. |
| | | multilineata. | 4 | 18 | Int. Region of Eastern prov. |
| Pupadæ. | Isthmia | ovata. | 1 | | Eastern & Central prov. |
| | Pupilla | pentodon. | 1 | | Northern-Eastern prov. |
| | Leucochila | armifera. | | | Eastern prov. |
| | | corticaria. | | | Eastern prov. |
| | | fallax. | 3 | 5 | Central portions of Eastern prov. |
| Auriculidæ. | Carychium | exiguum. | 1 | 1 | Interior & Eastern portions of Eastern prov. |
| 8 | 25 | 42 | 42 | 42 | |

* The *provinces* are those defined by W. G. Binney, *vide* "Terr. Moll." v, p. 17, *et seqq.* It is, of course, understood that all such divisions are more or less arbitrary.




## EXPLANATION OF PLATE V.

Figs. 1–4. *Limnophysa desidiosa* Say.
4. Recent.
Figs. 5–11. *Limnophysa humilis* Say.
9–11. Recent.
Figs. 12–16. *Succinea avara* Say.
15–16. Recent.
Figs. 17–19. *Patula striatella* Anth. Fossil.
Figs. 20–24. *Helicina* (*Oligyra*) *occulta* Say.
23–24. Recent.
Figs. 25–29. *Stenotrema monodon*, Rack.
28–29. Recent.
Figs. 30–34. *Patula strigosa* Gould.
33–34. Recent.
Figs. 35–44. *Succinea obliqua* Sar.
35–36. Recent.

NOTE ON THE TABLES.—No species has herein been listed, either of recent or fossil forms, on tradition or authority. Local examples of every form mentioned have been under examination in framing them.

forty-two. These forms are distributed among twenty-five subgenera comprised in eight families. Of the families not included in table I, the *Ancylinæ*, *Viviparidæ* and *Valvatidæ* are exclusively fresh-water in distribution, while the *Rissoidæ* comprise both fresh-water and marine genera. Those enumerated are fresh-water only. The facies of molluscan life seems therefore to have become decidedly more aquatic in recent times.*

Some of the forms indicated in table I are widely distributed both in time and space, while several of the subgenera attain a very high antiquity.† Of the families the oldest terrestrial group is the *Helicidæ*‡ represented by *Strophites grandævus* Dawson, from the Erian plant-beds of St. John, New Brunswick. The subgenus *Conulus* dates back to the Carboniferous, being represented by *Conulus priscus* Carp., from the South Joggins, Nova Scotia. Of equal age is the subgenus *Pupa*, represented by four species described in the paper last above cited. *Vallonia pulchella* and *Strobila labyrinthica* have each a great antiquity, the last named having, however, the widest distribution. The former is circumpolar, is a hardy species, and is known to abound at comparatively great altitudes.§ Binney quotes Prestwich (Quart. Jour. Geol. Soc., xxvii, p. 493) as authority for this species in the Red and Norwich Crag.‖ Its wide distribution is suggestive of its great antiquity. The second of these species, *Strobila labyrinthica*, is a representative of a now almost exclusively American subgenus, one of whose species, however, occurs in Jamaica. It is distributed over all the Eastern provinces of Binney. From the Eocene of England is recorded an extinct *Helix* referable to this species. According to Bland the fossil *Helix labyrinthica* from France "is apparently identical with our species." Binney¶ quoting Whiteaves (Can. Nat., vol. viii, p. 56,) records *H. labyrinthica* from the Upper Eocene at Headon Hill, Isle of Wight, and in the Paris Basin. *Helicina* (*Oligyra*) *occulta* may be properly considered the characteristic fossil of all löss-deposits in the valley of the Mississippi.

In similar deposits to that now under consideration in Belgium many of the same genera and some few of the same species are found. This is really an important fact as establishing the former wide geographical distribution of forms now confined almost solely to one or the other of the two continents.

* For some interesting generalizations respecting the *origin* of our land-mollusks as illustrated by the fossils of the Mississippi Valley, *vide* Binney "Terr. Air-Breathing Moll., vol. v. pp. 28–30."

† *Vide* this Journal, vol. xx, pp. 44–49.

‡ *Vide* Dawson on "Palæozoic Land-Shells," this Journal, vol. xx, p. 414.

§ *Vide* Hemphill, Quart. Jour. of Conch., p. 128, 1877.

‖ *Vide* "Terr. Air-Breathing Moll.," vol. v, p. 343.

¶ *Op. cit.*, p. 259.

From the recent alluvium and löss-like beds at Thiede, near Wolfenbüttel, the following genera, found in our area, have been taken, along with others confined to Europe:* *Pupa*, *Cionella*, *Helix*, *Vallonia*, *Patula*, *Hyalina*, *Succinea* and *Limnæa*. The *Succineæ*, like those of our area, are pretty abundant (Ziemlich haüfig). The species common to the two localities are *Pupa muscorum*, *Helix* (*Vallonia*) *pulchella*, and *Cionella lubrica*.† In the löss deposits at Würzburg,‡ the same species and the following genera were found: *Lymnæa*, *Pupa*, *Cionella*, *Helix* and *Succinea*. From a third locality, "Die Fuchelöcher am Rothen Berge bei Saalfeld," was obtained but a single species—*Pupa muscorum*—and four genera—*Patula*, *Hyalina*, *Pupa* and *Succinea*—common to our area. A similar comparative paucity is noted in the list from the löss of the Rhine at Unkelstein, near Remagen, where were found *Helix*, *Pupa* and *Succinea*, with *Helix* (*Vallonia*) *pulchella* and *Pupa muscorum* common. In every case in these localities were found the fossil remains of vertebrata, comprising bones of mammals, fishes, batrachians and birds.

Independent of its geological bearing, table I affords some data of great interest from a zoological stand-point. A comparison of the columns of measurements will lead to the important generalization that the fossil forms enumerated are depauperate. Only those specimens were measured which were perfect, or nearly so; the entire number of measured specimens being over one thousand. The forms of *Stenotrema monodon* present some important differential characters, the apices being more elevated, the whorls more convex and somewhat loosely coiled, with apertures more lunate than in recent specimens. The reflected portions of the lip and the parietal teeth are also less calcareous. In all other respects they correspond generally with the variety of the recent form known as *Stenotrema monodon*, var. *Leaii*. The *Patula strigosa* present, in a remarkable degree, those features determined by Professor Alpheus Hyatt§ as characteristic of lessened vitality or even of traumatism. The average diameter of this species, as is seen by the table of measurements, falls far below the normal. The form described as *Patula Cooperi*, but now quite properly placed in the synonymy of *P. strigosa*, is in excess of all the others assumed by this protean species, all of which, however, are much smaller

* *Vide* "Zeitschrift der Deutschen geologischen Gesellschaft, vol. xxxii, p. 472, (1880).

† We have here retained the nomenclature adopted by the author quoted. The weight of authority, however, would make this species a synonym of *Ferussacia* (*Cionella*) *subcylindrica*, and hence identical with the American form.

‡ *Op. cit.*, pp. 494, 496, 503 and 508, for this and the following lists.

§ "On the Tertiary species of Planorbis at Steinheim." Anniversary Mem. Bost. Soc. Nat. Hist., 1880, p. 13 *et seqq*. This memoir is a most important and valuable contribution to the literature of evolution.

than the specimen serving as the type.* None of the measurements of the *Pupadæ* are given in the table, partly because in attempting to measure them many were broken, and partly, again, because the differences in size appeared to be so small as to be almost inappreciable and hence do not appear to affect the general value of the observations. *Succinea* seems to have attained a most luxuriant development, and is exceeded in numbers only by *Oligyra occulta*. This last species is of remarkable interest from the fact of its recent discovery living in great numbers in the vicinity of Iowa City. In all the recent specimens examined, upwards of one hundred and fifty, the smallest of the living forms were larger than the largest of the fossil ones. The two aquatic species, *Limnophysa humilis* and *Limnophysa desidiosa*, present the same depauperate features and lead us to the same general conclusions. Plate V figures both recent and fossil forms of these several species in juxtaposition, the specimens figured illustrating quite well the most common variations and the relative sizes. (See explanation.)

In this connection it will be found of great interest to consult the remarks of Semper‡ on the influence exerted on animal life by low temperatures. That author experimented on *Lymnæa stagnalis*, and the results of his long continued observations led to the statement that the *Lymnæa* may be quite frozen up without being killed. Extremely low temperature had no influence on the animal life, but entirely prevented growth.‡ In this way a permanently diminutive race might arise. At all events the fossil material studied by the junior author, comprising many hundred examples, presents the *fact* of such depauperate races whatever may have been the cause.

## IV.

In order to state intelligibly the working hypothesis suggested by the foregoing facts, it will be necessary to briefly state the conclusions as to the formation of åsar and the determination of river courses reached by the senior author after a practically exhaustive survey of the cenology of the northeastern quarter of Iowa.§

The ice-sheet over this region was thin; not more than five hundred feet in average thickness. Each pre existing plateau or ridge accordingly produced a relatively considerable attenuation of the sheet. Three results followed: (1) The motion of

* *Vide*, "Terr. Air-Breathing Mollusks," vol. v, p. 158, fig. 64.

† *Vide* "Animal Life, as affected by the Natural Conditions of Existence," 1881, p. 108–109, and elsewhere.

‡ *Op. cit.*, p. 108. *Vide*, also, Darwin "On the Origin of Species by means of Natural Selection." Edition of 1877, p. 54.

§ A memoir embracing the results of this survey is approaching completion.

the ice was retarded along the ridge, and the pressure was reduced, thereby not only diminishing the rate of erosion, but heaping up an unusual thickness of morainic debris along the ridge in what may be styled a *submedial morain*. (2) The attenuation of the ice brought the fine debris undoubtedly disseminated throughout the lower portion of the ice to the surface in unusual quantities, thereby facilitating superficial melting along the ridges, and thus determined the course of a supra-glacial stream. (3) The rapid melting of the ice along such lines so reduced its thickness and diminished its pressure upon the subjacent surface as to divert thither all sub-glacial water, which accordingly formed sub-glacial streams coincident and finally confluent with the supra-glacial rivers. These streams formed cañons in the ice, and when eroded through, either formed basins or extended their corrasion into the subjacent deposits, according to the slope of the surface. In either case, when the cañons were long, the streams so deeply corraded their beds before the bounding walls of ice disappeared as to permanently retain the water-ways in the ridges over which they were first defined; while, when the cañons were short, the streams left the ridges as soon as they reached the margin of the ice.

Passing now to the region shown in the accompanying map, we find to the eastward a typical *as* in which the ice-cañon was too short to define a water-way, and about the confluence of the rivers a plateau which formerly existed as an ice-bound basin, and through which the rivers corraded their valleys before the final disappearance of the ice. In such a basin the löss was deposited, just as was all of that of eastern Iowa; the coldness of the waters and the low temperature of the air being attested by the depauperate shells found imbedded in it. Here, however, a re-advance of the glacier occurred before the ice was melted from the plains east of Capitol Hill and west of Walnut Creek, which disturbed, contorted and broke up the superficial portions of the löss, and mingled its materials with the clays and bowlders of a super-imposed sheet of drift; the re-advance being too slight to completely remove the löss even from exposed localities.

*Apropos* to the re-advance of the ice-sheet here suggested is Upham's discovery that Des Moines lies approximately in the course of the southernmost lobe of the great terminal moraine.* Now, if the phenomena are coincident, as is forcibly suggested, it follows that, as has already been urged by Chamberlin,† this moraine was formed, not during an independent ice-period,

* Ninth Annual Report of the Geological and Natural History Survey of Minnesota, p. 304, Plate VI (1880).

† Geology of Wisconsin, 1873–1877, ii, pp. 214, 218.

but during a temporary halt and slight re-advance of the slowly retreating ice-sheet which formed the drift without its limits.

Incidentally the observations herein recorded indicate (1) from the essentially homogeneous and unquestionably unipartite character of the drift-sheet above the löss, especially in section 6, that the Torrellian hypothesis of the deposit of a *ground-moraine* and a *superficial moraine* by each glacier is invalid; (2) from the disappearance of the blue coloration downward in sections 6, 8 and 10, that this blue color is not normal and changed to brown or yellow by oxidation from above, as urged by Hawes,* Julien,† Von den Bruch,‡ Shaler,§ and others, but is in some way acquired.

May 31, 1882.

---

ART. XXIV.—*Orthocynodon, an animal related to the Rhinoceros, from the Bridger Eocene;*‖ by WM. B. SCOTT and HENRY F. OSBORN.

ORTHOCYNODON is the name given to designate a new genus of the Rhinoceros line from the Bridger Beds of Wyoming. It was discovered by the Princeton Expedition of 1878, in the Bad Lands of Bitter Creek. It carries the Rhinoceros line farther back than it has been supposed to exist. The oldest representative of this line known hitherto is *Amynodon*, a genus found by Professor Marsh¶ in the Uintah beds which overlie the Bridger. Orthocynodon was at first referred to the latter genus, until important differences in the molar dentition were discovered.

*Generic characters.*—The lower canines are erect and functional, giving the name to the genus. The lower incisors are two on each side and semi-procumbent. The lower premolars, with the exception of the first, are somewhat simpler than the molars, but have the Rhinoceros pattern of two inward-opening crescents directed forwards. The upper premolars have distinct posterior crescents and small postero-internal cusps. The post-glenoid and post-tympanic processes apparently do not unite to surround the external auditory meatus. There is a sagittal crest separating the temporal fossæ.

This genus differs from *Amynodon* in the erect canines, in

* Geology of New Hampshire. 1878, iii, p. 333.

† Proc. A. A. A. S., 1879, xxviii, p. 352.

‡ Mémoire sur les Phénomènes d'Altération des Dépots superficiels par l'infiltration des eaux Météoriques, 1881, pp. 147–168.

§ Glaciers, 1881, p. 165.

‖ Description from specimens in the E. M. Museum of Geology, Princeton, N. J.

¶ This Journal, III, vol. xiv, p. 251.

the possession of a posterior crest, and distinct though small postero-internal cusp on the second and third upper premolars; finally, in the fact that the premolar pattern in both jaws is like that of the molars. In *Amynodon* the canines are nearly procumbent and the premolars are all unlike the molars. It is singular that this genus, belonging to a more recent geological formation than *Achaenodon*, should have less of the typical Rhinoceros structure in its molars.

*Orthocynodon antiquus*, gen. et sp. nov.,

Dental formula, $i\ \frac{2-2?}{2-2}$, $c\ \frac{1-1}{1-1}$, $pm\ \frac{3-3?}{4-4}$, $m\ \frac{3-3}{3-3}$

The specimens consist of the skull and lower jaw of one individual, and a portion of the skull containing the molar series of another. In each the upper canines and incisors are wanting. The lower incisors are close to the canines; they are semi-erect in position and placed in a quarter circle. They have slight fangs and sharp crowns, with low cingula posteriorly. The canines are almost trihedral in section and curve upwards and slightly backwards, worn at the back of their pointed tips by the upper teeth. A diastema of two inches separates them from the premolars. The lower premolar-molar series differs only in size and minor details from that of a young specimen of *Rhinoceros Indicus*. The first premolar has a simple crown rising to a single point and supported on two fangs. The inner face is irregularly concave, as in the Rhinoceros. Each of the remaining teeth presents two forward opening crescents of similar pattern. The third and fourth upper premolars are preserved in our specimens, and the upper molars are complete. The premolars present an external longitudinal ridge; from it arise a broad anterior and a narrow and somewhat low posterior crescent, opening backward; the postero-internal cusps are small. The molars are like those of the Rhinoceros in the proportion and disposition of their crescents.

The *Skull* is about fourteen inches long and five inches deep. The occipital condyle resembles that of the Indian Rhinoceros. There is a recurved *paroccipital* process having a long forward union with the post-tympanic. The *post-tympanic* and *post-glenoid processes* do not unite as in the modern Rhinoceros. In common with all the Eocene Ungulates there is quite a high thin sagittal crest, and somewhat deep temporal fossa, quite unlike the Indian Rhinoceros. The skull in fact does not resemble that of its modern relative. The *parietals* are narrow and compressed; the *frontals* expand into a broad well-rounded snout. We cannot ascertain from our specimens whether the nasals bore protuberances for the support of horns. It seems probable that they did not.

This animal will be fully described and figured in a later publication. The above is intended merely as a preliminary notice. *Orthocynodon* may be briefly described as an Eocene perissodactyle Ungulate with the premolar-molar dentition of a Rhinoceros, and somewhat resembling *Amynodon* in the possession of canines and loss of the median incisors. It has little of the rhinocerotic character in the skull, but the resemblances in the dentition point it out as related to *Amynodon*, with which it belongs, among the group of Eocene progenitors of the Rhinocerotidæ.

MEASUREMENTS.

| | M. |
|---|---|
| Total length of molar series of the lower jaw | ·192 |
| Antero-posterior diameter of the first lower molar | ·038 |
| Transverse diameter of the first lower molar | ·022 |
| Vertical diameter of the crown of the canine | .040 |
| Transverse diameter of the first upper molar | ·035 |
| Antero-posterior diameter of the first upper molar | ·035 |
| Total length of the upper molars, estimated | ·165 |

## SCIENTIFIC INTELLIGENCE.

### I. CHEMISTRY AND PHYSICS.

1. *On the Atomic Weight of Carbon.*—ROSCOE has re-determined the atomic weight of carbon by the method employed by Dumas and Stas, which consists in the direct combustion of the diamond. For this purpose diamonds from the Kimberley mines, South Africa, were used, those burned by the French chemists having come from Brazil. The method employed was the same, carefully purified oxygen being conducted over the diamonds contained in a tarred platinum boat placed in a glazed tube of Berlin porcelain, which was heated in a charcoal fire. The products of combustion were absorbed (1) by a weighed U-tube containing pumice moistened with sulphuric acid, (2) by two series of Geissler-Liebig potash bulbs, containing potash solution; (3) by three U-tubes containing pumice wet with a solution of caustic potash, and (4) two small U-tubes containing pumice and sulphuric acid. Six separate experiments were made. In the first, six small transparent stones of a pale yellow color were used; in the second eight small dark stones; in the third one large dark stone; in the fourth four dark stones; in the fifth four colorless stones, and in the sixth a piece of the black diamond known as carbonado. Assuming Stas's atomic weight for oxygen 15·96, the values obtained for carbon in the six experiments were as follows: 11·970, 11·978, 11·970, 11·976, 11·966, 11·995; mean, 11·9757. The mean value obtained by Dumas and Stas in 1840 is 11·9708. With the exception of the sixth experiment, in which the black variety of carbon was used, the hydrogen obtained

did not exceed as a mean one seven-thousandth part of the weight of the diamond, and was probably derived from moisture in the apparatus. In presenting this memoir to the Academy, Dumas called attention to the fact that if the atomic weight of oxygen be assumed as 16, that of carbon is 12·002, or within one-six-thousandth of a whole number.—*C. R.*, xciv, 1180, May, 1882.—*Ann. Chem. Phys.*, V, xxvi, 136, May, 1882. G. F. B.

2. *On the Determination of Chromium as Phosphate.*—CARNOT has proposed to determine chromium as phosphate. When a feebly acid solution of a chromium salt is boiled with sodium acetate and phosphate, the whole of the chromium is thrown down as phosphate. The method succeeds not only with the green salt but also with the violet ones, and with chlorides, sulphates and acetates, but not with oxalates. The chromium in chromates may be determined in this way if sodium thiosulphate be added simultaneously to reduce the chromic acid. The precipitate is a green hydrate having the formula $Cr_2P_2O_8$, $(H_2O)_6$ when dried at 100°. It may be washed with boiling water, in which it is nearly insoluble, or better with hot solutions of ammonium acetate and nitrate. On ignition it loses its water and becomes $Cr_2P_2O_8$, containing 51·86 per cent of chromium. Aluminum and chromium are readily separated by converting the latter into chromate, precipitating the former as phosphate, then reducing and precipitating the chromium as phosphate, as already described. The chromium phosphate the author believes to have a commercial value as a green pigment.—*Bull. Soc. Ch.*, II, xxxvii, 482, June, 1882. G. F. B.

3. *On the Earth-metals of Samarskite.*—ROSCOE has made a study of the rarer earth-metals occurring in samarskite. About 1·5 kilos. of the coarsely-powdered mineral were treated in portions of 100 grams, with 250$^{cc}$ commercial hydrofluoric acid, diluted with an equal volume of water. The solution was decanted from the precipitate, and this after being well dried was heated with sulphuric acid, and after separation of the uranium the earths were precipitated as oxalates. The oxalates on ignition yielded oxides which were converted into nitrates, fused, dissolved in water, the solution precipitated with potassium sulphate, converted into neutral sulphates and by a series of fractional precipitations separated into two groups. One of these gave a sulphate soluble in 30 parts of a cold saturated solution of $K_2SO_4$. Its oxide was of a fawn color, and it contained philippia, yttria, terbia, and traces of erbia. The other sulphate was soluble only in 200 parts of the $K_2SO_4$ solution, and gave a brown oxide. It contained didymium, decipium, $\beta$-yttrium, etc. The oxides from the former portion weighed 60 grams; from the latter 25 grams. The first group of these oxides were converted into formates and these submitted to a long and systematic series of fractional precipitations, the powdered mass being extracted with successive small volumes of hot water, each extract being evaporated to dryness and analyzed. In this way a large num-

ber of fractions were finally obtained, one of which was richest in philippia, another in terbia and another in yttria. All attempts, however, to obtain a formate possessing a constant atomic weight of 121–123 failed entirely. In view of the curious fact that the formate which yields an atomic weight nearest to 122 possesses distinctly different physical properties from the formates obtained from oxides of much higher or much lower atomic weight, some direct experiments were made. To test the question whether this result was due to the crystallization together of the higher and lower formates, a mixture was made of the formates of yttrium and terbium, in three solutions, each containing different proportions. One of these solutions yielded rhombic crystals exactly like those previously obtained. Hence it appears that the formates of terbium and yttrium are capable of crystallizing together in a form ascribed to philippium.—*J. Chem. Soc.*, xli, 277, June, 1882. G. F. B.

4. *On the Precipitation of Glycogen.*—It is well known that in the preparation of glycogen from animal tissues the amount of material precipitated on the addition of alcohol is often very slight. KÜLZ has examined this question and found that as the product is purified by repeated precipitation, the yield becomes less. Having prepared 49 grams of glycogen from a dog's liver it was analyzed and found to contain 0·16 per cent of ash. After drying at 110° C., it was dissolved in water. But the addition of even 4 or 5 times the volume of absolute alcohol produced no precipitate. That the drying had no effect was shown by the fact that a glycogen, containing 1·3 per cent of ash and so dried, dissolved in the proportion of 0·5 to one gram to 100$^{cc}$ of water, and was readily precipitated by absolute alcohol. But on repeating the process on the same sample a point was soon reached where its purity was such that no precipitation took place. The addition of a minute quantity of salt, even 0·002 gram, produces a precipitate at once. The author calls attention to the similarity in the behavior of this body to the salt-free soluble serum-albumin of Aronstein.—*Ber. Berl. Chem. Ges.*, xv, 1300, June, 1882. G. F. B.

5. *On the Transformation of Urea into Cyanamide.*—Many chemists have studied the conditions under which cyanamide, through the influence of dilute acids, takes up the elements of water to form urea, $CN_2H_2+H_2O=CON_2H_4$. But the dehydration of urea into cyanamide has not hitherto been effected. FENTON however, after numerous experiments in this direction, has succeeded in accomplishing it by means of sodium. If urea be gently heated with metallic sodium the reaction is violent and a large amount of hydrogen is evolved. On dissolving the solid residue in water, the solution gives the reactions of cyanamide. The crystallized product gave on analysis the formula $CN_2H_2$. The reaction by which it is formed is as follows:

$$(CON_2H_4)_2+Na_2=(CN_2H_2)_2+(NaOH)_2+H_2.$$

Sodium acts upon ammonium carbamate and carbonate in the

same way and produces cyanamide, though the yield is not as abundant as with urea.—*J. Chem. Soc.*, xli, 262, June, 1882.

G. F. B.

6. *Oscillation of the plane of polarization by the discharge of a battery.*—BICHAT and BLONDOT have studied the effect of a Leyden jar discharge in producing a rotation of the plane of polarization in a transparent medium. The body is placed between the polarizer and analyzer, arranged for extinction in a bobbin, which is wound round with a long fine wire. A discharge takes place when the difference of potentials is sufficient; at this instant a bright reappearance of light is seen by the eye situated in front of the analyzer, showing a rotation of the plane of polarization. A mirror, rotating on a vertical axis, was now placed before the optical apparatus; the polarizer was provided with a vertical slit whose image was observed in the rotating mirror by a telescope, the arrangement being such as to cause the appearance of the spark at the right instant. In general, a series of broad luminous bands was observed corresponding to the oscillatory currents of the discharge. Further, it was observed that the rotation of the analyzer through a small angle in one direction caused the even bands to grow weaker and the odd ones to increase, and *vice versa* for a rotation in the opposite direction. From this it is concluded that the plane of polarization undergoes successive rotations alternately in opposite directions, or in other words, it oscillates about its normal position, each oscillatory discharge corresponding to an oscillation of the plane of polarization.

The authors also arranged the apparatus so that there could be seen at once in the rotating mirror, the bands furnished by the light of the spark, and those due to the oscillation of the plane of polarization. The two systems of bands, alternately bright and dark, were seen one above the other. It was found that the two systems corresponded exactly, so that the two phenomena must be considered to be simultaneous; no difference in time as great as $\frac{1}{30\,000}$ second could be observed.—*C. R.*, June 12, 1882.

## II. GEOLOGY AND NATURAL HISTORY.

1. *On the relative ages and classification of the Post-Eocene Tertiary deposits of the Atlantic Slope;* by ANGELO HEILPRIN. 36 pp. 8vo. (Proc. Acad. Nat. Sci. Philad., June, 1882.)—Mr. Heilprin reviews the facts respecting the post-Eocene fossils both geographically and stratigraphically, by comparisons between those of Maryland, Virginia, North Carolina, and South Carolina. He finds that of 103 lamellibranchs found in South Carolina about 74 per cent occur also in North Carolina, showing probable equivalence of deposits; while in Virginia only 42 per cent of the S. Carolina species occur, and 46 of those of N. Carolina, and but 33 to 34 per cent in Maryland, indicating apparently a difference in horizon. Again, of the Virginia lamellibranchs, 109 species, only 40 per cent are common to South and 44 to North

Carolina; and of the Maryland, 98 in number, the percentage in the Carolinas is 35 to 37 per cent; while 42 per cent are common to Maryland and Virginia. These facts sustain the inference that the deposits of North and South Carolina are of one horizon, while those of Virginia and Maryland are of another or two others.

Again, of the South Carolina species, about 33 per cent (omitting six doubtful) are recent forms and of the North Carolina, 30 per cent. Of the 109 Virginia species, the recent are only 16 in number or 15 per cent; and of the 98 Maryland, only 13. These facts further corroborate the view of two distinct horizons. The conclusions are sustained though less strikingly, by a review of the gasteropod fauna. Mr. Heilprin hence concludes that the Virginia deposits belong to a horizon older than that of the Carolinas, and that the Maryland indicates two horizons of which the upper one corresponds to the Virginian. Finally, the subdivisions of the Tertiary of the Atlantic and Gulf border are thus tabulated.

| | | | |
|---|---|---|---|
| PLIOCENE. | ? | ? | |
| MIOCENE. | CAROLINIAN (Upper Atlantic Miocene). | Deposits of South and North Carolina ("Sumter" epoch of Dana). | |
| | VIRGINIAN (Middle Atlantic Miocene). | Deposits of Virginia, and of the "Newer" group of Maryland ("Yorktown" epoch, in part, of Dana). | Probably equivalent of the "Second Mediterranean" of Austria, and of the fahluns of Touraine. |
| | MARYLANDIAN (Lower Atlantic Miocene). | Deposits of the "Older" group of Maryland, and possibly the lower Miocene beds of Virginia ("Yorktown" epoch, in part, of Dana). | Probably (or at least partially) equivalent of the "First Mediterranean" of Austria, and of the fahluns of Léognan and Saucats. |
| OLIGOCENE. | ORBITOITIC. | Strata characterized by species of *Orbitoides*, etc. Vicksburg beds, Florida beds, etc. | |
| EOCENE. | JACKSONIAN. | Jackson beds of Mississippi—"White Limestone" of Alabama. | |
| | CLAIBORNIAN. | Fossiliferous arenaceous deposit of Claiborne, Ala., etc. | Age of the "Calcaire Grossier" of France (Parisian). |
| | BUHRSTONE. | Beds below the true Claibornian on the Alabama River. "Chalk Hills" of the southern portion of the State, etc. "Siliceous Claiborne" (Hilgard) of Mississippi. | Londonian? |
| | EO-LIGNITIC. | Lignite, sands, and clays situated at the base of the Tertiary series in Alabama, etc. Eocene beds of Maryland? | Thanetian? |

2. *On the Classification of Lake Basins*, by Wm. M. Davis.—This paper makes nearly 70 pages of vol. xxi of the Proceedings of the Boston Society of Natural History. It reviews the kinds of lake-basins and considers their modes of origin. Among the conclusions presented are the following: that the Great Lakes of North America are not a result of glacial excavation; that while there are rock-basins of moderate size which are presumably of glacial origin, these are far outnumbered by drift-barrier basins and drift basins; that the presence of drift and alluvial barriers below the Swiss lakes, so far as effective, obviate the necessity of considering them orographic or glacier-erosion basins; that the kettle-holes and other depressions over the drift deposits, unstratified and stratified, may in part have originated in hollows occupied by isolated ice-masses during drift deposition, as suggested for American examples by Upham (an explanation applied by Peschel, as Mr. Davis states, to account for the preservation of Lake Neufchatel and its neighbors), or they may be spaces which the drift in its uneven accumulation failed to fill.

3. *The Catskill region.*—A paper on the Little Mountain, east of the Catskills, by Wm. M. Davis, giving instructive sections of the rocks of these elevations and of the region between the Catskills and the Hudson, is contained in vol. iii of Appalachia, No. 1.

4. *Address before the Geological Society at the anniversary meeting in February*, 1882; by Robert Etheridge, Esq., F.R.S., President of the Society. 204 pp. 8vo.—This presidential address of Mr. Etheridge consists chiefly of a memoir "on the analysis and distribution of the British Jurassic fossils." The subject is discussed with great thoroughness, both stratigraphically and paleontologically. The number of genera recognized is 513, of species 4488; and of these species 6 are Mammals, 132 Reptiles, 219 Fishes, 115 Belemnites, 477 Ammonites, 6 Teuthids, 21 Nautili, 1 Aneyloceras, 1015 Gasteropods, 924 Dimyaries, 444 Monomyaries, 275 Brachiopods, 51 Bryozoans, 64 Crustaceans, 45 Annelids, 216 Echinoderms, 175 Cœlenterates, 100 Rhizopods, 11 Amorphozoans and 191 Plants. The address closes with a review of the modern classification of Ammonites.

5. *Artificial forms of Silica.*—Some curious artificial forms of silica, interesting as illustrating the structure of agates and chalcedonies, have been described by J. I'Anson and E. A. Pankhurst. To illustrate the stalactitic, or exogenous, type of agates, the best results are obtained as follows:

"A strong solution of an alkaline silicate is taken, containing a certain amount of alkaline carbonate, and a strong acid (sulphuric seems to give the best results) is introduced by means of a pipette to the bottom of the vessel in which the solution is contained. Bubbles of carbonic acid gas immediately arise, carrying with them a certain amount of the stronger acid. Round the stream of ascending bubbles silica is deposited by the decomposition of the alkaline silicate, and in a very few minutes a tube is formed reaching from the bottom to the surface of the solution. This

tube is at first very thin, and through its walls the ascending acid continues to act upon the surrounding silicate, the walls of the tube in consequence constantly growing in thickness by the deposition of additional silica on its outer surface. As long as the flow of acid is kept up, so long does the tube grow in diameter by the deposit of successive layers, and the result is a hollow stalactite ringed in cross section.

"The carbonic acid evolved from the carbonate in the solution is essential to the successful commencement of the tube, but when this is once formed, the sulphuric or other acid can be itself forced through it, and by the application of pressure to the surface of the fluid in the pipette, the action can be kept up for a long time, and stalactites of ¾ inch in diameter can be formed with little difficulty. The same result can be produced by passing an acid gas, or even air highly charged with an acid, through the alkaline silicate solution, and it will easily be seen that analogous effects can be produced by the action of any other reagents capable of separating the silica, such as acid salts of various metals. In fact, the process can be varied in a hundred different ways. In natural siliceous stones, where stalactitic forms enter into the structure, we constantly observe a central core, frequently of iron or other oxide, which appears to represent the original tube which has subsequently been filled up, whilst sometimes the cavity remains more or less completely as such. These stalactites of course do not grow up by any means in constantly straight regular forms, but assume irregular and branched ones, more like those of coral than anything else, according to the direction in which the bubbles of gas or the acid escapes from the end, or from points of least resistance in the sides of the tube. Glauber's "Iron tree" is one form of this stalactitic growth. * * *

"We consider, then, that the stalactitic productions thus made are the analogues of all the group of banded stalactitic growths which enter so largely into the constitution of many siliceous stones, where the growth appears to have proceeded from a central cavity, now frequently only a core by reason of subsequent filling in.

"If the action is carried so far that the surrounding fluid becomes saturated with acid reagent, the whole of this surrounding fluid gelatinizes by the precipitation of amorphous gelatinous silica, and if we suppose a case in which such stalactitic forms have been produced in nature in an enclosed rock cavity containing an alkaline silicate solution, by the infiltration of an acid solution, a like result would occur. In point of fact, as we have already stated, such natural forms constantly occur with a surrounding mass of crystallized unbanded silica, and this we are led by many observations to regard as the analogue in nature of the gelatinous silica resulting from the saturation of the fluid in which the stalactites have been formed. Whether in nature this crystalline silica has been originally deposited in a gelatinous form, and subsequently crystallized, is a little out of the scope of this paper; but analogy leads us to regard this as most probable."

With reference to the banded or endogenous type of agates the authors remark:

"Assuming hypothetically a rock cavity containing a solution of alkaline silicate, and the rock in which this cavity is situated permeated with an acid solution or gas, we should naturally expect to find a layer of silica deposited on the walls of such a cavity, and, as the action continued, more and more silica would be deposited; and if the solution were *enclosed* in the rock cavity, the central portion would, when the action had continued to a certain point, set in an amorphous mass. This action is very completely paralleled in some of the preparations which we have made, and in some of these we have found that a central vacant space was left, owing to there not being enough silica in the solution to fill the whole cavity when precipitated in the gelatinous form. This is precisely what occurs in many natural agates, where we find a deposit of crystalline unbanded silica within the banded portion, with a vacant space in the center of all."

By the use of acid solutions containing various metallic and earthy salts the coloring of natural stones can be imitated, that is, jaspers, moss agates, onyx and so on. The horizontal banding frequently met with in natural agates has been also very completely reproduced. When the precipitated silica in these preparations is exposed to the air it, for the most part, dries up and crumbles away, although some forms closely like common opal in appearance but of lower specific gravity have been produced. Under suitable conditions as to heat and pressure the authors think that the natural agates and allied varieties might be imitated, not only as here in form but also in hardness and stability.—*Min. Mag.*, May, 1882.

6. *The Origin and Relations of the Carbon minerals*, by Professor J. S. Newberry. 24 pp. 8vo. From the Annals of the N. Y. Acad. Sci., vol. ii, 1882.—Professor Newberry, on reviewing the relations of the carbon minerals, considers the question as to the origin of the mineral oil, and opposes the view that it is indigenous in the sand-rocks which hold it, expressed by Professor Lesley (Proc. Amer. Phil. Soc., x, 33, 187), on the ground that the fossil remains of plants in such sand-rocks are very few, if not often wholly absent. He presents the old view as the most probable—that the sandstones through their porosity were convenient receptacles for the oil which flowed from some stratum of organic matters below.

7. *Lehrbuch der Mineralogie* von Dr. Gustav Tschermak, II. Lieferung, pp. 193–368. Vienna, 1882 (Alfred Hölder).—This second part of the valuable new Mineralogy by Professor Tschermak (see this Journal, xxiii, 68) contains the remainder of the physical portion of the subject, the chemistry, the discussion of method of occurrence and of paragenesis of minerals, the classification, and the beginning of description of species.

8. *New Swedish Minerals.*—Professor L. I. Igelström has recently described two new minerals from Wermland, Sweden. Man-

GANBRUCITE occurs at the manganese mines of the Jakobsberg together with hausmannite, jakobsite, piedmontite, manganophyllite, braunite, etc. It is found in granular form, of the size of hemp seed, in the hausmannite ore, consisting of hausmannite more or less thickly imbedded in calcite. Massive, without cleavage; color from honey-yellow to brownish-red, perhaps originally nearly colorless; translucent in thin splinters. An analysis gave, after deducting a very little silica and calcite:

| MgO | MnO | $H_2O$ |
|---|---|---|
| 57·81 | 14·16 | 28·00 = 99·97 |

This corresponds approximately to the formula (Mg, Mn) $H_2O_2$, or a manganesian variety of brucite.

TALKTRIPLITE is from Horrsjöberg in Wermland, where it occurs with lazulite, svanbergite which it much resembles, and other phosphates. It is found in grains of the size of a pin-head; color yellow to yellowish-red; transparent; hardness about 5. An analysis of 0·85 gram of the mineral mixed with matrix (0·585 insoluble in HCl) gave:

| $P_2O_5$ | FeO | MnO | CaO | MgO |
|---|---|---|---|---|
| 32·82 | 16·12 | 14·86 | 14·91 | 17·42 = 96·13 |

It contains some fluorine, which, however, was not determined. The calculated formula is $(Fe, Mn, Mg, Ca)_4P_2O_9 + CaF_2$, but the analysis is too imperfect to determine the composition with certainty. The author suggests that perhaps the true formula is $R_3P_2O_8 + RF_2$, and then the mineral would be essentially a triplite containing lime and magnesia. The name given has reference to this supposition.

9. *The female Flowers of Coniferæ.*—Professor Eichler's paper on this subject, reviewed in the May number of this Journal, has induced Professor CELAKOVSKY to re-investigate this subject, morphologically so important, and to which he had already devoted much attention. In the Abhandl. d. K. Boehm. Ges. d. Wiss. he has recently published his present views, in an extensive article, illustrated by a plate. After reviewing the different theories and explanations enunciated since Robert Brown's time, he dwells emphatically on the great importance of the study of the *anamorphoses* (as he calls those monstrosities which are the result of retrograde metamorphosis, in contra-distinction to mere pathological alterations) and of the teachings they convey. He comes to the conclusion that these are a much safer guide than the microscopic study of the genesis of the organs, which has often misled those who too implicitly relied on its teachings. Investigating the anamorphoses of the Norway spruce, he finds the two lateral carpellary leaves distinctly indicated and more or less separated and developed. In more evolved cases an anterior and then a posterior bract make their appearance; these, Professor Eichler had taken for a third and fourth lobe of his ligula. It must be stated here that normally the posterior bract is the third and the anterior the fourth in order. Celakovsky comes to

the conclusion that, at least in *Abietineæ*, Eichler's theory (that the carpellary scale is a mere emergence or ligule of the bract) is quite wrong, and that Mohl's view (1871)*—that the carpellary scale of these plants consists of the two connate lowest leaves of an axillary, otherwise undeveloped, bud connate at their upper edge and producing the ovules on their back,—is amply vindicated by all known morphological facts and is antagonistic to none of them.

He further concedes that the same explanation may possibly be the true one for all conifers, and that all morphologists who have treated this question thus far, have, whatever their views, assumed a conformity in this respect in all the tribes of conifers, and a complete homology of their female organs. But he thinks that this is not necessarily so, and that Sachs' and Eichler's emergence- or ligular theory may be true as to *Araucarieæ*, and that thus the cone of these plants is really and truly a single flower. In regard to *Taxodineæ* and *Cupressineæ* he is convinced that an inner fruit scale really exists, completely adnate to the bract and soon outgrowing it, but he does not venture to pronounce on its nature, because he thus far has no ocular demonstration of it through any anamorphosis.† Professor Celakovsky concludes that the arillus of *Taxaceæ* corresponds with the ligula of *Araucarieæ*. He speaks of the *terminal* position of the ovule in this tribe as of very little morphological importance, being really a lateral ovule pushed to the top of an axis.‡

It will be of interest to those who have been misled by contrary statements, to learn that O. Heer, the celebrated phyto-paleontologist, has shown that geologically *Abietineæ* and *Taxodineæ* are the oldest conifers now known, appearing already in the Carboniferous period, while *Araucarieæ* come up much later in the Trias and Jurassic formations. But relative geological age of the different tribes of plants is of much less importance for the appreciation of their degree of development and their position in the system than some suppose. Thus the *Cycadeæ*, the Phænogams

* It appears now that A. Braun has expressed the same view as early as 1842 in the French *Congrès scientifique* at Strasburg, in the report of whose proceedings it is published. He often threw out such hints from the rich treasures of his investigations, but with characteristic modesty he gave them to science without urging them or claiming scientific property or priority in them.

† The writer of this is in possession of a proliferous cone of *Sequoia gigantea* which seems to prove, not only that the fruit scale in this species (and consequently in the whole tribe) is homologous with that of *Abietineæ*, in so far as it consists of leaves of an axillary shoot, yet that these leaves are not a single pair, but, as A. Braun has long ago suggested, in regard to *Cupressineæ*, that there is a number of leaves, laterally coördinate and connate, bearing a number of ovules on their back.

‡ It might be well to draw attention to the singular fact, that in the allied gymnospermous family of *Gnetaceæ*, the female flower (for such it is now assumed to be, the outer integument or utricle being considered as a two-leaved carpel) is always referred to as "terminal," whether single, double or triple, while a terminal organ can not be otherwise than single. The fact is that the female flowers are here axillary in the axils of one or more of the uppermost bracts, and, if single, are pushed to the top of the shoot.

most closely allied to the vascular cryptogams, are, as Professor Heer states, very uncertain in the Carboniferous, and make their decided appearance first in the Permian rocks; therefore much later than the higher developed conifers. G. E.

10. *Report by* S. I. SMITH *on the Crustacea*, Part I, Decapoda. One of the Reports on the results of Dredging under the supervision of A. Agassiz, on the east coast of the United States, during the summer of 1880, by the U. S. Coast Survey Steamer "Blake." 108 pp. 8vo, with 16 plates. Cambridge, June, 1882.—This report forms No. 1, vol. x, of the Bulletin of the Museum of Comparative Zoology. Among the new species described in this excellent paper, there are a Lithodes, *L. Agassizii*, and a remarkable species of the family Eryontidæ, *Pentacheles sculptus*, besides others of much interest. Four new genera of Macrurans are made out, *Rhachocaris* of the Crangonidæ, *Meningodora* and *Eumiersia* of the Pandalinæ, and *Amalopenæus* of the Penæidæ. The plates have the perfection which comes from accurate drawings copied by photolithography.

11. *Fragments of the coarser anatomy of Diurnal Lepidoptera*, by SAMUEL H. SCUDDER. 84 pp. 12mo. 1882. Reprinted from volume iii of Psyche.—The anatomical notes contained in this little volume are on the larves and pupæ of *Danais Plexippus*, *Aglais Urticæ* and *Hamadryas Io*, and the larves of *Polygonia C. album*, *Callophrys Rubi*, *Eurymus Philodice*, *Euphœades Troilus* and *Epargyreus Tityrus*. The author speaks of the very few articles which have thus far appeared on the internal anatomy of Lepidoptera, and observes that the accounts here contained of his dissections of caterpillars and chrysalids are published "more in the hope of calling attention to the need of work of this kind than of directly contributing to general statements deducible from the observations."

12. *Memoirs of the Boston Natural History Society.*—The third volume of the quarto Memoirs of this Society thus far published, contain the following papers: on *Distomum crassicolle*, by C. S. Minot, 20 pp., with one plate, 1878; Early Types of Insects, by S. H. Scudder, 9 pp.; Palæozoic Cockroaches, by S. H. Scudder, 112 pp., with five plates; New Hydroids from Chesapeake Bay, by S. F. Clarke, 8 pp., 8vo, with three plates, January, 1882; *Archypolypoda*, a subordinate type of spined myriapods from the Carboniferous Formation by S. H. Scudder, 40 pp., with four plates, May, 1882.

## III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Berliner Astronomisches Jahrbuch für* 1884 *mit Ephemeriden der Planeten* (1)-(220) *für* 1882.—This the 109th volume of the series is prepared, as for several years past, under the direction of Dr. TIETJEN. The ephemerides of the small planets form as usual the distinctive feature.

In the Jahrbuch for 1883 there was a great increase in the

number of stars of which the apparent or mean places were given. The mean places are now given for 622 stars, and the apparent places of 450 of these at least as often as each ten days. The preparation of the large catalogue of the *Astronomische Gesellschaft* makes desirable this increase in the number of the fundamental stars, whose places are fully given.

In the Appendix Dr. Anwers compares the places of the stars given in the Jahrbuch with those in the Am. Ephemeris, the Nautical Almanac, and the Connaissance des Temps, all for the epoch 1883·0. The numbers in the several almanacs are as follows:

| | Total. | B. J. | A. E. | N. A. | C. T. | Common to all. |
|---|---|---|---|---|---|---|
| Ephemeris stars, | 599 | 450 | 208 | 197 | 309 | 111 |
| Total stars given, | 791 | 622 | 383 | 197 | 309 | 133 |
| South of −32 Dec., | 51 | --- | 44 | 15 | 18 | --- |

The right ascensions and declinations of the whole 791 stars are compared individually, and both the systematic and irregular small differences are shown between the Jahrbuch and the other three Ephemerides. H. A. N.

2. *Transit of Venus.*—The three missions designated for observation of the Venus transit in Patagonia left on the 20th ult. in the Messageries steamer from Bordeaux, for Buenos Ayres. The arrangement is as follows:—*Rio Negro* (41° S.), M. Perrotin, director of Nice Observatory, accompanied by Lieutenants Tessier and Delacroix, and M. Guénaire, photographer to the Observatory; *Chubut* (43° S.), M. Hatt, hydrographic engineer, assisted by Lieut. Leygue and M. Mion, engineer; *Santa Cruz* (50° S.), Capt. Fleuriais, assisted by Lieutenants Le Pord and de Royer de Saint Julien, and M. Lebrun, naturalist. Arrived at Monte Video, the first two missions will probably embark in the advice boat *La Bourdonnais*, the third in the advice boat *Le Volage*. In the course of observations, detachments from the *Volage* will try to ascend the Rio Santa-Cruz at least to the point reached by Darwin in the Beagle expedition. The Chili mission, composed of Lieut. de Bernardière, assisted by Lieut. Barnaud and Ensign Favereau, embarked on the 15th ult. in an English steamer going by the Straits of Magellan.—*Nature*, Aug. 3.

From the United States, a party goes to *Santa Cruz*, Patagonia, in charge of S. W. Very, U. S. Navy, with O. B. Wheeler, assistant astronomer, Wm. Bell, photographer, and Irvin Stanley, assistant photographer.

3. *Report upon Experiments and Investigations to develop a System of Submarine Mines for defending the Harbors of the United States*—submitted to the Board of Engineers by Lieut.-Col. Henry L. Abbott, Corps of Engineers. 444 pp. 4to, with 27 plates. Washington, 1881. (Professional papers of the Corps of Engineers, U. S. A., No. 23.)—This valuable volume contains a portion of the results of a long series of experiments and investigations carried on under the charge of General Abbott since 1869, and bearing upon the general subject of submarine

mining. The topics discussed in the three chapters of the work now made public are: sub-aqueous explosions, electrical fuses, and modes of ignition. The remaining chapters of the complete report will treat of kindred topics, relating to submarine mines, torpedo cables, fish torpedoes, and so on; being of a confidential nature they will be printed only for the use of the School of Submarine Mining at Willets Point.

Chapter I, having the general head of Sub-aqueous Explosions, contains a description of the apparatus used for the measurement of the force of the explosion; the physical phenomena observed; a mathematical analysis giving an expression for the available kinetic energy developed by explosions of various kinds for the unit of surface exposed; and a discussion of the various kinds of explosive mixtures and compounds with which experiments were made. In chapter II, the subject of electrical fuses is exhaustively treated of; the fuses are divided into three classes: the low tension fuses used with powerful electrical currents of low potential where the effect is accomplished by the heating of a very fine wire, through which the current is passed; the "high tension" fuses used with electricity of high potential, the sensitive priming being ignited by a spark which jumps across a break in the metallic circuit; and finally the fuses of "medium tension" specially designed for use with magneto-electric machines where the electricity generated has a higher potential than that of the voltaic current but less than that of the frictional machine; in the last case also the ignition is accomplished by the passage of a spark at a break in the circuit. The fuses of the second and third classes differ from each other in the chemical composition and electrical resistance of the priming. In Chapter III, the various forms of igniting apparatus are described; these are, the frictional apparatus of various types with a generator of frictional electricity and a condenser; the voltaic induction apparatus involving the familiar principles of the induction coil; the many kinds of magneto-electric and dynamo-electric machines; and finally, the voltaic batteries. Appendices A, B, C, contain details of experiments made with the rings, crate, and iron target.

This general statement as to the contents of the volume will give some idea of its scope. The experiments and investigations of General Abbott have been carried on with so much judgment and energy, and the results are here discussed with so great thoroughness, that the importance of the volume can hardly be overestimated; it is of value not only in its bearing upon harbor defenses in case of war, but also to all engaged in harbor improvements, rock blasting and other similar work. The frontispiece is a heliotype reproduction of one of a series of six instantaneous photographs taken during the destruction of a schooner blown up at Willets Point by the simultaneous explosion of two torpedoes, containing each 50 pounds of mortar powder, suspended 10 feet apart and 3 feet below her bottom amidships.

This picture was taken one-tenth of a second after the explosion, and shows the bow and stern plunged in the water and the middle of the vessel raised about 16 feet; the masts were still vertical and the jet of water had reached a height of about 70 feet. Another picture, taken after 1·5 seconds, showed a water column 160 feet high; and a third, 2·3 seconds after the explosion, showed the jet at its maximum height of 180 feet, the air being full of fragments not yet descending. At the end of 4·3 seconds all evidences of violent action were gone.

4. *Professional papers of the Signal Service.*—The U. S. Signal Service has begun the issue of what promises to be a most valuable series of papers under the above title. The first number is by Professor Abbe and consists of the Signal Service Reports on the Total Solar Eclipse of July, 1878. The second is a series of twelve maps of the monthly isothermal lines deduced from the observations of the years 1871–80, by Lieutenant A. W. Greeley. The third is a chronological list of Auroras observed from 1870–1879, compiled by Lieutenant A. W. Greeley. The fifth is on the construction and maintenance of time balls, and contains ten or twelve letters of persons who have had special experience in managing these time signals. The sixth paper is by Mr. H. A. Hazen on the reduction of air pressure to the sea level at elevated stations west of the Mississippi River.

5. *Celebrated American Caverns, especially Mammoth, Wyandot and Luray, together with historical, scientific and descriptive notices of caves and grottoes in other lands*; by Horace C. Hovey. 228 pp. 8vo, with maps and illustrations. Cincinnati. 1882. (Robert Clarke & Co.)—The author of this volume is an enthusiastic explorer of caverns. He has spent much time in the study and enjoyment of the scenes they afford, the discovery of new passages, and the examination of the various objects of interest by the way; and his cave-wanderings have extended to numerous caverns besides those mentioned in the title. Moreover, in the preparation of his work he has gathered material from a wide range of literary and scientific accounts of caverns, cavern products and cavern inhabitants. His volume, therefore, while popular in style, and dealing much in the marvelous, and in scenic descriptions manifesting his intense appreciation of his subject, has also a scientific importance. The maps of the underground passages of the Mammoth Cave and others are of special interest. The complicated reticulations through so great areas present a difficult problem to the geologist, for which he has now only the most general explanations—such as are contained in a reference to joints; bedding, harder and softer or impurer layers alternating; erosion by corroding carbonated waters, by direct abrasion, and to some extent through nitrification and the products of pyrites-decomposition. The facts of scientific interest are partly given in Mr. Hovey's paper in volume xvi (1878) of this Journal. Luray cavern in Luray Valley, near the village of Luray, Page County, Virginia, was little explored or known before 1878. It is much

smaller than the Wyandot, but is more remarkable for its stalactitic hangings and the consequent beauty of its passages and chambers.

The illustrations of the volume in general present well, and not extravagantly, some of the scenes of the caverns.

6. *Scientific Survey connected with the Northern Pacific railroad.*—The directors of the northern Pacific railroad and of the Oregon railway and Navigation Company selected, nearly a year ago, Professor Raphael Pumpelly, as director of a survey of the lands in the vicinity of the railroads crossing the continent westward, entitled the "Northern Trans-continental Survey." The objects in view are the discovery and testing of deposits of coal or ores or other useful materials, the examination of timber lands, the investigation of soils, and the study of whatever may affect the resources and value of the region. Professor Pumpelly's head-quarters at the present time are Helena, Montana. He has associated with him Professor E. W. Hilgard in the department of soils; Dr. H. A. Hazen of Harvard, entomologist, with S. Henshaw as assistant; Professor A. D. Wilson, chief topographer, with L. Nell and R. U. Good, assistants; Professor Sargent of Harvard, department of forestry; Professor W. M. Canby, department of forest plants; and B. Wilson, G. H. Eldridge and B. T. Putnam as geologists. The laboratory of the survey is at Newport, Rhode Island, where Dr. F. A. Gooch is chief chemist, and W. T. Richmond assistant. A communication to the New York Sun, from which the above facts are taken, states that "by the time the northern route to the Pacific is open, on the 1st of July, 1883, it is probable that the results of the survey will in part be given to the public.

Mémoire sur la Géologie de la partie Sud-est de la Pennsylvania. Thesis présentées a la Faculté des Sciences de Lille. Université de France, pour obtenir le grade de Docteur ès-sciences naturelles, par PERSIFOR FRAZER, A.M. 176 pp. roy. 8vo, with plates and maps. Lille. 1882.

The Elements of Forestry, particularly adapted to the wants and conditions of the United States, by Franklin B. Hough, Ph.D. 382 pp. 8vo. Cincinnati. 1882. (Robert Clarke & Co.)

Forest Trees of California, by A. Kellogg, M.D. 148 pp. 8vo. State Mining Bureau, Henry G. Hanks, State Mineralogist, State Office, Sacramento. 1882. A popular treatise.

## DARWIN MEMORIAL.*

Large additions are due from America to the Darwin Memorial Fund. All naturalists, and all thinkers with few exceptions, know that they have been greatly enriched in knowledge, and raised to a higher level of thought and study, as a consequence of Darwin's labors in science. Feelings of gratitude are hence natural; and the memorial affords an opportunity for their substantial expression. There is special satisfaction in honoring one who sought only truth--not honor—in his life-work. J. D. D.

* Page 159 of the last number of this Journal.

OBITUARY.

General Gouverneur Kemble Warren.—General Warren died at Newport, Rhode Island, on the 8th of August, in his sixty-fourth year. On graduating at the West Point Military Academy in 1846, he was assigned to the Corps of Topographical Engineers. With the exception of two years—from 1859 to 1861—as Professor of Mathematics at West Point, and active service in the war from 1861 to April, 1865, his labors were chiefly in connection with the department of United States Engineers, and they comprise many of the most important and responsible works carried forward by the department. The surveys of the Mississippi and other rivers with reference to improvement of navigation, construction of breakwaters, bridging, and reclamation of alluvial lands, became under him a source of important geological discussions on the formation of sand bars, the relations of deposition to the flow of meeting streams, the changing courses of rivers, and other related subjects. In the study of the Upper Mississippi, the surveys were extended, in 1876, along the chief northern tributary, the Minnesota; and the observations made were the basis of a Report to the Chief of Engineers the following year, and more fully later, on the former discharge of Lake Winnipeg through the Minnesota and Mississippi valleys. General Warren found in the facts evidence of a great change of level in the land over the interior of North America. The paper is one of the most important contributions to geology and physical geography that has appeared, and will have far-reaching effects on the science.

General Warren received the commission of Brevet Major-General United States Army, in view of his gallant and meritorious services in the war.

George P. Marsh, long American Minister to Italy, eminent as a linguist, and an able statesman, author of "The Origin and History of the English Language," "Man and Nature," "The Earth as Modified by Human Action," and other works, died in July at Vallambrosa, near Florence, at the age of eighty-one. He was born at Woodstock, Vermont, on the 27th of March, 1801, and graduated at Dartmouth College in 1820.

Professor M. F. Balfour, author of a "Treatise on Embryology" and other works, the "ablest member" of the School of Science of Cambridge, England, lost his life in July, on Mont Blanc. As the Athenæum of July 29 states, though only thirty-one years of age, Mr. Balfour had taken the first place among English men of science.

Edward Desor.—A full list, by Dr. Geinitz, of the publications of Mr. Desor, whose death was announced on page 422 of the last volume of this Journal, is contained in Part 4 of Isis (Dresden) for 1882. The first appeared in 1840, and related to the glaciers of Monte Rosa and Monte Cervino: the last, in 1881, on the Fossil Man of Nice.